Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle*

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I. EXECUTIVE SUMMARY

I.1. Introduction

Concentration, structural change, and market performance in the beef packing industry continue to raise questions and concerns from cattle producers across the nation. In addition, many of the slaughtering firms are relying, to an increasing degree, on "non-cash purchases" as a means of procuring cattle. (Non-cash purchases are often referred to as "captive supplies," and include forward contracts, marketing agreement/formula purchases, and packer fed cattle.) A key question is whether packers' use of non-cash procurement methods has the effect of depressing cash ("spot market") prices paid for cattle. Because the results of prior research have been equivocal, the Grain Inspection, Packers and Stockyards Administration (GIPSA) has commissioned this study to measure the effects of non-cash purchases on prices paid for fed cattle during the period and in the region of investigation. GIPSA collected detailed data on the cattle procurement activities of four large beef packing plants in the Texas panhandle region (the Excel plants at Friona and Plainview, the IBP plant at Amarillo, and the Monfort plant at Cactus) over the period from early February 1995 through mid-May 1996. These data were provided to Professors John R. Schroeter (Iowa State University) and Azzeddine M. Azzam (University of Nebraska - Lincoln) the cooperating investigators and authors of this report. The research was carried out in fulfillment of Cooperative Agreement No. 98-PPD-01, "Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle," USDA, GIPSA.

I.2 Scope of the Inquiry

Concerns about the relationship between packers' use of non-cash procurement methods and the spot market price of fed cattle have raised at least two distinct questions. One question, arising from what we might call a "long-run" perspective on the matter, is: "How is the spot market price affected by a change in the overall proportion of annual fed cattle slaughter that is attributable to non-cash procurement methods?" A clear understanding of the nature of this long-run relationship would be essential for predicting the changes in market conditions that would occur if currently practiced non-cash procurement methods were to be prohibited or sharply restricted by law. Another question, viewing the matter from a short-run perspective, is: "How is spot market price affected by packers' and feeders' decisions about the volumes of non-cash cattle to deliver to packing plants in a particular week?" A clear understanding of the nature of this short-run relationship is needed to determine whether the capability exists for one party to use short-run supply-sourcing strategies as a means of "manipulating" spot market prices to the detriment of another party. The data collected in the GIPSA investigation are only suited to an analysis of the short-run, not the long-run, question. Consequently, the main focus of this report will be the short-run (week-to-week) relationship between the delivery volumes of cattle procured by non-cash methods and the spot market price of fed cattle. As a prelude to that main inquiry, however, we also use the GIPSA data to address two related preliminary issues: Does the quality of cattle vary across procurement methods? Do the quality-adjusted prices paid for cattle vary across procurement methods?

I.3. Non-cash Procurement and the Cash Market Price: Research Procedure

In our investigation of the short-run relationship between the use of non-cash supply sources and the spot price of fed cattle, we sought to answer four questions:

1. Who is responsible for deciding how many cattle procured by non-cash means will be delivered to a packing plant within any given week? How far in advance of delivery is that determination made?

2. What is the empirical relationship, in the short-run, between the use of non-cash supply sources and spot market prices?

3. What economic mechanisms could be behind the empirical relationship?

4. Does the nature of the base price in the formula used to price marketing agreement cattle influence a packer's spot market pricing conduct?

Addressing the first question sets the "ground rules" and insures that the underlying assumptions of the econometric analysis square, as much as possible, with real practice. It is crucial to the analysis that one does not assume, *a priori,* that the decision to deliver non-cash cattle rests exclusively with one transacting party or the other.

Addressing the second question establishes whether the empirical regularity, found in previous studies, of a negative relationship between the use of non-cash procurement methods and spot prices, is also present in the 95/96 Texas panhandle data. Empirical regularities are useful pieces of information when stable and robust over different regions, time periods, and statistical methods. But they do not, by themselves, constitute evidence of a causal relationship *from* the use of non-cash methods of procurement *to* spot market price determination. They do, however, serve as a guide to questions needing further investigation.

The third question inquires about possible explanations for the often-found negative relationship between non-cash procurement and spot cattle prices. It is our opinion that this is one area to which previous research on the impact of non-cash procurement methods has given insufficient attention. Normally, the inquiry ends with the demonstration of a statistical relationship. But with no notion of an economic mechanism responsible for the statistical relationship, there is no way of knowing what should be made of it. In this report, we propose a specific economic mechanism that could account for the negative relationship.

The last question addresses the possibility of strategic behavior by packers in the manipulation of the base price of marketing agreement pricing formulas. The hypothesis here is that the relationship between marketing agreement cattle deliveries and spot market prices may differ depending upon the type of base price used in the pricing formula. In particular, when the formula base is derived from the plant's average hot cost, rather than a USDA reported price, packers may be able to conduct their spot market activities so as to manipulate the formula base to their advantage. The data are checked for telltale signs of this sort of manipulative conduct.

I.4. Findings

We began the empirical analysis with a preliminary investigation of differences in cattle quality and quality-adjusted price across procurement methods. Insofar as cattle quality is concerned, some generalizations are revealed by a casual comparison of means and standard deviations of quality indicators, by procurement method. For example, marketing agreement purchases appear to contain a higher proportion of all-steer lots (as opposed to all-heifer or mixed sex lots) and have a higher lot average yield than do spot market purchases. In a case such as this, for which commodity "quality" is multidimensional, it is possible to develop a one-dimensional, dollar-value index of quality using a product characteristic approach. In our application of this approach, we used data on spot market prices paid for lots of fed cattle to determine the spot market's implicit valuations of a variety of lot attributes. Using these estimated lot attribute valuations, it is possible, for each fed cattle lot in the data set, to estimate a "price" at which the lot would have sold had it been transacted on the spot market on a given day. These hypothetical "prices" can be used as indexes of lot "quality" that are comparable across procurement methods. The results of this exercise did not produce evidence of systematic differences in cattle quality across procurement methods. It should be noted, however, that the analysis was hampered by the fact that the data set did not contain information on all potentially important lot quality characteristics. For example, little information was available on the degree of uniformity of cattle within each lot.

To investigate the possibility of differences in quality-adjusted prices, we used a regression analysis to explain the delivered prices paid for spot market, forward contract, and marketing agreement lots of fed cattle in terms of lot quality indicators, other factors which may influence price (like the identity of the purchasing plant and the week of purchase), and a set of variables which, for each plant separately, identified the procurement method. The results of this analysis indicated that all four plants appear to pay quality-adjusted delivered price premia for marketing agreement cattle, relative to spot market cattle, that ranged from a low of $0.52/cwt. (on a carcass-weight basis) to a high of $2.26/cwt.

also appear to pay quality-adjusted price premia for forward contract cattle, relative to spot market cattle. Estimates of these premia range from about $2.00/cwt. to about $2.50/cwt. We can only speculate about the sources of these apparent premia. In the case of marketing agreement cattle, they could be reflections of the transactions cost savings packers experience by employing marketing agreements or they could merely be statistical artifacts due to omission of data on some potentially relevant lot quality attributes. In the case of forward contract cattle, there is some tentative evidence to suggest that these price "premia" are attributable to futures market performance that, over the period of investigation, happened to favor basis forward contract sellers over buyers.

Again, this study's main line of inquiry concerns the short-run relationship between the use of non-cash procurement methods and the spot market price for fed cattle. We review our findings with regard to each of the four questions defining our research procedure.

Question 1.

As part of the investigation, GIPSA personnel interviewed feedyard owners and managers about various aspects of fed cattle markets including the terms of their marketing agreements with packers. From our review of the reports of these interviews, the following conclusions, pertinent to question 1, were reached.

A. For the most part, the number of cattle to be delivered by a feeder, to a plant, under a given marketing agreement, within a given week, is determined by the feeder. In some cases, it appears that packers may occasionally amend the delivery numbers submitted by feeders.

B. The number of marketing agreement cattle to be delivered by a feeder within any one week is normally determined two weeks in advance of delivery.

C. Once the volume of marketing agreement deliveries for a given week is set, the packer has discretion over the specific day or days of the week upon which delivery will be made.

With regard to forward contract cattle, standard basis forward contract (which we assume to be typical of basis forward contracts used by other packers) stipulates that "The cattle shall be delivered *on a day designated by Buyer* during the delivery month, or by mutual agreement at an earlier or later date." (emphasis added) Anecdotal evidence suggests, however, that delivery timing is usually a mutual decision between the buyer and the feedlot, with an effort made to deliver cattle when their optimal potential is reached. We assume that the timing of forward contract cattle delivery is determined primarily by the packer. Once the decision to deliver is made, there can be a time lag attributable to delays in arranging for transportation. For the majority of forward contract lots, the data record the date on which the lot was scheduled for delivery as well as the date on which the lot was killed. Examination of these data suggests that the decision to deliver forward contract cattle is normally made either one or two weeks in advance of delivery.

During the period of investigation, packer fed cattle were not used at all by plant, constituted only a very small share of slaughter for the but did represent a significant percentage of all cattle killed by the Obviously, the packer has complete discretion over when to utilize packer-owned supplies of cattle.

Question 2.

In addressing question 2, we make a point of distinguishing between two different "levels of analysis" at which the short-run empirical relationship between the use of non-cash procurement methods and spot prices can be explored. At the "plant level," we investigate whether packing plants that anticipate relatively large volumes of non-cash cattle deliveries in the near-term future tend to pay spot market cattle prices that are low *relative to regional average prices*. At the "regional level," we examine the relationship between the weekly slaughter, by the four Texas plants combined, of cattle procured by non-cash means and the week's average spot market price of fed cattle in the Texas panhandle region.

When a packing plant purchases cattle on the spot market, it is purchasing those cattle, not for immediate slaughter, but to fulfill slaughter needs for some future period. It stands to reason that a plant's spot market pricing conduct would be influenced, at least to some extent, by the proportion of the future period's desired slaughter that is already met with pre-scheduled deliveries of cattle from non-cash sources (assuming, as seems justified, that non-cash cattle deliveries for the near-term future are known, at least roughly, by the packer). So it makes sense to search the data for a connection between a packer's near-term future slaughter of non-cash cattle and the prices the packer is paying for spot market cattle "today."

One problem, of course, is that it is not obvious how the relevant "near-term future" is appropriately defined. In our empirical work, we examine the relationship between the spot prices a packer pays "today" and its relative degree of reliance on non-cash supply sources in the future using a variety of plausible "planning horizons" as bases for the definition of future non-cash supply usage. We find that packers who expect relatively "large" volumes of non-cash cattle deliveries in the near-term future *do* tend, other things equal, to pay "low" spot market prices relative to regional averages. As for the magnitude of the effect, regression results suggest the following generalization: If a typical plant's non-cash cattle supply proportion of near-term future slaughter were to increase by ten percentage points relative to its rivals' degrees of reliance on non-cash supply sources, then we would expect the spot market prices paid by that plant, for cattle of given quality, to fall somewhere between 0.02 $/cwt. and 0.04 $/cwt. (on a live-weight basis) relative to regional average prices.

In our investigation of the relationship between non-cash procurement methods and price at the regional level, we regressed various measures of weekly average fed cattle prices in the Texas panhandle region on measures of the four-plant combined weekly use of cattle procured by non-cash means and other control variables. Using weekly time series data and various combinations of variable definitions and statistical techniques, a robust empirical relationship was found in every case: The slaughter of cattle procured by non-cash means and contemporaneous spot market prices are negatively related at the regional level. The results, moreover, when taken at face value, suggest that the impact of non-cash procurement methods on price is reasonably substantial. Suppose for example, that the weekly volume of non-cash cattle deliveries to the four Texas plants were to increase from its 66-sample-week average level (about 26,400 head) by one sample standard deviation (about 7730 head). The estimation results, taken at face value, imply that the other-factors-held-fixed impact of this change would be a decrease in the spot price by $0.69/cwt. (on a live-weight basis).

The regression results, at the plant level and at the regional level, uncover a stable and robust empirical regularity between the use of non-cash procurement methods and spot market prices that is generally consistent with the findings of previous studies. However, the question of what to make of the findings still remains. Is the relationship indicative of noncompetitive or "abusive" pricing conduct on the part of packers? Do increases in aggregate non-cash cattle deliveries *cause* the spot market price to fall? Or, for that matter, does the causality run in the other direction: Do low spot market prices create an incentive to deliver large volumes of cattle from non-cash supply sources? Until the nature of the economic mechanism responsible for the empirical regularity is established, its policy relevance will remain questionable. This leads to question 3.

Question 3.

To understand the economic mechanism responsible for the short-run empirical relationship between the use of cattle procured by non-cash methods and spot market prices at the plant level, one must recognize that any given regional market, at any given point in time, is characterized not by a single price, but by a distribution of prices for fed cattle. Prices paid for individual lots of cattle vary, in part, because of lot-to-lot variation in cattle quality. But they also vary due to random variation in the strength of competitive forces throughout the market area. On a given day, a feedyard in one part of the region may be visited by only one buyer and, consequently, receive relatively "low" bids. In other parts of the region, competition among bidders from two or three firms may be the norm and transaction prices may be higher.

When a packer enters the spot market knowing that a relatively large proportion of its typical slaughter volume is committed, for the near-term future, in the form of already-scheduled deliveries of cattle procured by non-cash means, it will usually want to purchase correspondingly fewer spot market cattle. This can normally be accomplished with relatively conservative bidding. As a result, it will succeed in procuring the desired number of spot market cattle at relatively low prices where only one or, perhaps, no other bidders contend for cattle, but will generally be outbid (or will decline to bid in the first place) where it finds two rival bidders already vying to make purchases. When, on the other hand, a packer enters the market needing to secure a relatively large share of near-term future slaughter volume with cash purchases, bidding behavior must be more aggressive, and the resulting transactions prices correspondingly higher. So it is not surprising, as the empirical results of section VII.1 indicate, that packers with a relatively high non-cash supply proportion of near-term future slaughter will pay spot prices that are slightly below the regional average price, other things equal.

For a *given* distribution of transaction prices, it is of little or no consequence to feeders that packers who currently have a relatively high degree of reliance on non-cash supply sources tend, other things equal, to be the ones paying relatively low prices within the distribution. What matters to feeders is whether the use of non-cash procurement methods can *cause* the regional average price to fall, shifting the entire distribution downward. To be sure, the regional-level analysis did uncover evidence of a negative correlation between the weekly volume of four-plant-combined slaughter of non-cash cattle and the week's average spot market price for the region. The crucial question is: What economic mechanism is responsible for this empirical relationship? One candidate explanation has to do with the impact that current prices and the expectation of future prices have on the incentives of feeders and packers to schedule delivery of cattle procured by non-cash methods.

Marketing agreements normally give feeders the right to determine the number of cattle delivered in a given week, but require that they notify packers of this number two weeks in advance of actual delivery. Thus, in the current week, feeders determine the number of marketing agreement cattle they will deliver to packers two weeks hence. Under conventional pricing formulas, marketing agreement cattle delivered in two weeks will bring a price based on the spot market price paid for (non-formula) cattle next week. So the expectation of a "high" spot price next week, other things equal, will incline feeders toward delivery of a "large" volume of marketing agreement cattle in the week after next. At the same time, however, if feeders currently expect price in two weeks to be high relative to next week's price, they have an incentive to postpone delivery of some of those cattle until three weeks hence, when formula prices will be based on spot prices for the week after next. Consequently, we would expect that the number of marketing agreement cattle delivered two weeks from now will be positively correlated with this week's expectation of next week's spot market price, and negatively correlated with the forecast, formed this week, of spot market price in the week after next.

Now consider the incentives packers face when deciding on the scheduling of forward contract cattle deliveries. Because the typical lag between purchase and slaughter of spot market cattle is about one week, from the packer's point of view, forward contract cattle deliveries next week substitute for spot market purchases this week. Assume, for the moment, that the typical interval between scheduling and delivery of forward contract cattle is about one week. Then a "high" spot market price this week will prompt packers to economize on spot market purchases, to some extent, by scheduling a large volume of the fixed-price contract cattle deliveries next week. On the other hand, if packers, this week, forecast a "high" spot price for next week, they will hoard their limited inventory of forward contract cattle, reserving them for delivery in the week after next, when they can substitute for spot market cattle that would otherwise have to be purchased at next week's anticipated "high" price. Thus, we would expect the number of forward contract cattle delivered next week to be positively correlated with the current spot price and negatively correlated with the forecast, formed this week, of next week's spot price. Were we to assume, on the other hand, that the typical lag between scheduling and delivery of forward contract cattle is two weeks instead of one week, a similar result would obtain: Just as with marketing agreement cattle, delivery numbers for two weeks from now should be positively correlated with this week's expectation of next week's spot price and negatively correlated with this week's expectation of spot price the week after next. Econometric results provide some support for this theory. Evidence of the predicted correlations were found in the data; especially in the case of marketing agreement cattle, the most important non-cash supply source for the four Texas plants during the period of investigation.

To summarize, this intuitive model of the scheduling of delivery of cattle procured by non-cash methods suggests that when the capability exists for packers and feeders to intertemporally shift non-cash cattle deliveries in response to economic incentives dictated by changing market conditions, deliveries of marketing agreement and forward contract cattle will tend to be "high," other things equal, when the *ex ante* forecast of the spot market price is "low." But because the experienced market participants who make the scheduling decisions are undoubtedly quite good forecasters of price (at least over a relatively short forecast horizon such as one or two weeks), their *ex ante* forecasts are likely to be quite highly correlated with the *ex post* realizations of price. So the tendency for weekly non-cash cattle deliveries to be negatively correlated with the unobserved *ex ante* two- (or one-) week-ahead forecasts of price could manifest itself in a negative correlation between weekly non-cash cattle deliveries and the observed *ex post* realizations of price. This, of course, is exactly the kind of empirical regularity found in section VII.2 in our investigation of the short-run relationship between the use of non-cash cattle and spot price at the regional level.

This line of reasoning counsels caution in the interpretation of empirical findings like those of section VII.2. The tendency for spot market cattle prices to be "low," other things equal, in weeks in which the slaughter of cattle procured by non-cash methods is "high," does not necessarily mean that there is an underlying mechanism whereby large deliveries of non-cash cattle in a particular week cause that week's spot market price to fall. Even if the week-to-week fluctuations in a region's spot market price of fed cattle were generated completely independently of the region's use of non-cash procurement methods, the incentives that influence the delivery scheduling decisions of feeders and packers would still give rise to a negative correlation between the observed spot price and the volume of non-cash cattle slaughter in weekly time series data.

Question 4.

Although feeders determine the week in which marketing agreement cattle will be delivered, packers typically have two weeks advance notice of the volume of scheduled deliveries. When a packer anticipates an unusually large volume of marketing agreement deliveries in a given week, there would be an obvious incentive to try to reduce the pricing formula's base price so as to reduce the price that will have to be paid for the formula-priced cattle. When the base price is derived from a USDA reported price, however, there would appear to be little, if any, capability on the part of the packer to manipulate the formula base. When the base price is derived from a one- or two-plant average hot cost, on the other hand, the possibility exists that packers might manipulate the base through strategic conduct in their spot market (non-formula) purchases the previous week. This suggests the hypothesis that the relationship between marketing agreement cattle deliveries and spot market prices may differ depending upon the type of base price used in the pricing formula. In particular, when the pricing formula is based on the plant's average hot cost, there might be a tendency for the plant to pay relatively low spot prices, for cattle of given quality, in a week preceding a week in which a relatively large volume of marketing agreement cattle are delivered. When the pricing formula is based on a USDA reported price, any such tendency may be weaker or non-existent.

The econometric results do not lend support to the hypothesis that packers try to manipulate formula base prices through their pricing strategies in spot market purchases. When we compare marketing agreement deliveries that are base-priced on the basis of plant average hot cost, with marketing agreement deliveries that are base-priced on the basis of a USDA reported price, we find no systematic difference in the relationship between the volume of deliveries one week and the relative spot prices paid the previous week.

I.5. Recommendations

In light of our results, we recommend that the agency should not rely on the statistical finding of a negative correlation between the use of non-cash procurement methods and spot market prices as evidence of intent by packers to depress cattle prices through the use of non-cash procurement, or as evidence of the unintentional consequence of lower prices as a result of the use of non-cash methods. The agency should be cognizant, however, that certain pricing mechanisms may be more conducive to noncompetitive conduct than others. For example, it stands to reason that when the formula base price is derived from an "in-house" average hot cost rather than a USDA reported price, there is a potential for manipulation of the formula base through spot market pricing conduct. We make this cautionary note in spite of the fact that we found no clear evidence of such abuse in the Texas panhandle data. Also, should the trend toward increased use of non-cash procurement methods continue, thus further thinning the spot market, spot prices will become increasingly less reflective of the forces of supply and demand. Under those circumstances, the cash market may no longer be the appropriate point in the beef marketing channel at which the formula base price should be derived.

II. STATEMENT OF THE QUESTION

Concentration, structural change, and market performance in the beef packing industry continue to raise questions and concerns from cattle producers across the nation. Concentration ratios for the top four firms slaughtering fed cattle rose from 50 percent in 1985 to a high of 82 percent in 1994, but decreased to 80 percent in 1996.

In addition, the procurement and pricing methods used by many of the slaughtering firms are very complex and sophisticated. As the industry continues its rapid move toward value-based methods of pricing, the complexity of the procurement and pricing practices will increase. The role of non-cash purchases in the price determination process is subject to considerable debate in the industry and in the agricultural economics profession. (Non-cash purchases are often referred to as "captive supplies," and include forward contracts, marketing agreement/formula purchases, and packer fed cattle). The Grain Inspection, Packers and Stockyards Administration (GIPSA) has published, for public comment, proposed rules to restrict certain cattle procurement practices. **The question addressed is whether packer's use of non-cash procurement methods has the effect of depressing cash prices paid for livestock in the spot market.**

One of GIPSA's major responsibilities under the Packers and Stockyards Act is to ensure open, competitive marketing conditions for livestock and meat. Concerns surrounding enforcement in this area were the major topic of discussion and review by the Advisory Committee on Agricultural Concentration established by Secretary Glickman in 1996. The advisory committee specifically recommended increased monitoring and enforcement of the antitrust and regulatory policy.

III. OBJECTIVE

In view of this question, GIPSA's Ft. Worth field office has conducted a preliminary investigation of fed cattle procurement in the Texas panhandle. GIPSA has interest in determining whether procurement of cattle by packers during the period of the investigation is associated with potentially unfair, unjustly discriminatory, or deceptive practices to the detriment of livestock producers. Because of the complex interrelationships among the factors that determine prices paid for cattle, econometric analysis is needed to obtain defensible conclusions about the potential effects of various procurement practices on prices. The research reported here provides such analysis and was carried out in fulfillment of Cooperative Agreement No. 98-PPD-01, "Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle," USDA, GIPSA.

GIPSA has particular interest in determining whether packers' non-cash purchases of fed cattle affect transaction prices, as results from prior research have been equivocal. Thus, the objective of this project is to measure the use and effects of non-cash purchases on prices paid for fed cattle during the period of the investigation.

IV. BACKGROUND, MOTIVATION, AND SPECIFIC OBJECTIVES

Issues concerning the relationship between packers' use of non-cash procurement methods and the spot market price of cattle can be separated into two categories: long-run issues and short-run issues. Long-run issues have to do with the relationship between spot market price and the overall proportion of annual fed cattle slaughter that is attributable to non-cash procurement methods. An understanding of these issues would be required to predict how the spot market would likely be affected if packers' degree of reliance on non-cash cattle sources were to continue to increase, or if currently practiced non-cash procurement methods were to be prohibited or severely restricted by law. Short-run issues, on the other hand, have to do with the spot market price impact of packers' and feeders' decisions about the number of non-cash cattle to deliver to plants in a given week. An understanding of this relationship would be needed to determine whether short-run supply sourcing strategies can be used to manipulate spot market price.

The data collected in GIPSA's Texas Panhandle investigation represent the activities of only four plants and span a relatively short time period (from the week of February 5, 1995 through the week of May 12, 1996) in which there was no change in the institutional arrangements governing the use of non-cash procurement methods and little or no evident trend in the actual overall use of these methods.[1] Consequently, these data are of limited use for the investigation of long-run issues. The data are well-suited, however, to the investigation of short-run issues concerning the relationship between the use of cattle procured by non-cash methods and spot market prices on a week-to-week basis.[2] For this reason, the econometric analysis undertaken in this report will focus on short-run issues.[3]

In spite of this report's primary focus on short-run issues, we will briefly review the two most recent theoretical models of the long-run effects of non-cash procurement on spot market prices.[4] For reasons explained above, the Texas Panhandle data is not suited to what we would consider to be a serious test of these theories, but they can provide what amounts to anecdotal evidence bearing on the theories' applicability to the Texas Panhandle fed cattle market.

Love and Burton develop a model of a food processor (a beef packer, for example) that exercises monopsony power in its raw input (cattle) market. Adapting

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[1]For the four plants combined, and for the sample period as a whole, the proportions of steer and heifer slaughter attributable to each of the procurement methods were 5.24% for forward contract, 2.48% for packer fed, 21.00% for marketing agreement, and 71.29% for spot market. The corresponding proportions calculated separately for the first and second halves of the sample period were little different from the figures for the entire sample period: First half: 5.20% for forward contract, 2.59% for packer fed, 21.94% for marketing agreement, and 70.27% for spot market. Second half: 5.28% for forward contract, 2.35% for packer fed, 20.00% for marketing agreement, and 72.37% for spot market.

[2]The sample's proportions of weekly steer and heifer slaughter attributable to each of the procurement methods did show significant variation over the sample period. For example, the proportion of weekly steer and heifer slaughter attributable to forward contract cattle ranged, over the sample's 67 weeks of data, from a low of 0% to a high of 30.55%. The corresponding figures for the other procurement methods were; for packer fed cattle: low = 0.17%, high = 6.81%; for marketing agreement cattle: low = 8.96%, high = 31.95%; and for spot market cattle: low = 42.11%, high = 88.88%.

[3]Our investigation of the short-run relationship between deliveries of non-cash cattle and spot market prices will, however, have implications about the credibility of commonly-made claims regarding long-run issues. In particular, we will address whether the negative correlation between non-cash cattle deliveries and spot prices that is frequently found in weekly data is evidence that legal restrictions on the use of non-cash procurement methods would lead to an increase in spot market prices.

[4]We are grateful to Professors H. Alan Love and Richard Sexton for bringing these models to our attention.

and extending an analysis due to Perry, Love and Burton first show that the processor has a profit incentive to vertically integrate "upstream" into raw input supply, either through acquisition of some of the previously independent producers or through the exercise of some sort of vertical control, such as marketing agreements or long-term contracts of other kinds. This incentive arises because, in an unintegrated monopsony equilibrium, the market price of the raw input understates its marginal value to the processor.[5] The result is a production inefficiency: Too little of the input is used. By extending partial vertical control over input supply, the processor can internalize some of this efficiency loss while continuing to exercise monopsony power over the remaining, unintegrated suppliers.

Love and Burton's model yields no unambiguous conclusions about the effects of upstream vertical integration on spot market price, however. Without additional assumptions about the elasticity of supply by independent producers, the model could be consistent with a spot market price that increased, decreased, or remained unchanged with decreases in the proportion of input supplies procured on the spot market. One implication of their analysis is that the price paid to the input suppliers that are under the processor's vertical control (feeders with marketing agreements, for example) will, however, be higher than the price paid to independents in the spot market. Love and Burton cite Ward *et al.* for evidence that packers pay higher prices for cattle procured through marketing agreements than for cattle purchased in the open market. Similar evidence can be found in the Texas Panhandle data analyzed in this report.[6]

Zhang and Sexton develop a model of processor/input supplier interaction that takes explicit account of the spatial aspects of the market. In their model, two processors (rival packers, for example) purchase raw input (cattle) from a large number of independent producers (feedlots) that are spatially distributed in a market modeled as a line segment. Zhang and Sexton show that, by offering long-term contracts to suppliers near the boundaries of market areas, the processors can create a geographic buffer between them, enabling the exercise of a greater degree of monopsony power

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[5]The processor cannot exploit this divergence between price and marginal value because, without the ability to price discriminate, purchasing more input would require paying a higher price on the inframarginal as well as the marginal units purchased. The incremental cost of increasing input usage by one unit would exceed the market price of the input.

[6]In section VI.2, we report evidence that all four plants paid higher quality-adjusted prices for marketing agreement cattle than for spot market cattle and that the plant paid higher quality-adjusted prices for forward contract cattle than for spot market cattle.

over the remaining independent suppliers. In this scenario, the use of long-term contracts is a manipulative tactic that enables processors to benefit at input suppliers' expense.

The simplifying assumptions of the Zhang and Sexton model (only two competing processors; a geographic market area that is isomorphic to a one dimensional line segment) are necessary for analytical tractability, but they do make it somewhat difficult to translate their results to real-world market settings. If the Zhang and Sexton story captures the essence of packers' motivation for using non-cash procurement methods, it does seem clear, however, that we should see non-cash cattle being drawn from the "boundary" regions of each plant's market area. Under these circumstances, it seems likely that non-cash cattle would tend to be shipped farther on average than spot market cattle. Table IV.1 reports summary statistics, by plant and by procurement method, for the distributions, across lots of fed cattle, of the distances (in miles) that cattle were shipped to the plant. In every one of the four plants, the cattle lot shipped the farthest, among all lots, was purchased on the spot market. Moreover, in numerous instances, spot market lots were shipped farther on average than lots acquired by other methods. For spot market lots were shipped farther on average than marketing agreement lots and packer fed lots. For spot market lots were shipped farther on average than forward contract lots and marketing agreement lots. For spot market lots were shipped farther on average than forward contract lots and marketing agreement lots. And, for spot market lots were shipped (slightly) farther on average than packer fed lots. These features of the Texas Panhandle fed cattle market appear to be inconsistent with the predictions of the Zhang and Sexton model.

In the context of the Zhang and Sexton model, the strategic role of the "buffer" region of suppliers under long-term contract is to make it unprofitable for processors to "jump" the buffer and compete directly with a rival in the rival's spot market territory. So another *ad hoc* "test" of the applicability of the Zhang and Sexton model can be carried out by calculating the proportion of spot market purchases of fed cattle that were made from a supplier located closer to one or more of the rival packers' plants. Among the lots of fed cattle purchased on the spot market by the Excel-Friona plant, were purchased from feeders located closer to the IBP or Monfort plants than to Friona. For the Excel-Plainview plant, of spot market fed cattle purchases were from feedyards closer to IBP or Monfort. For the IBP and Monfort plants the proportions of spot market purchases from feeders closer to one or more of the other three plants were respectively. It appears, from these figures, that packers relatively frequently compete directly with rivals in the rival's spot market territory. To this extent, the stylized facts of the Texas Panhandle fed cattle market are not consistent with the Zhang and Sexton model.

Previous attempts by agricultural economists to econometrically estimate and explain the effect of non-cash purchases on fed cattle prices span over thirty years. From Aspelin and Engelman (1966) to Azzam (1996), there have been several studies including Hayenga and O'Brien (1990, 1991, 1992), Schroeder, *et al.* (1991a, 1991b, 1992, 1993), and Ward *et al.* (1996). Though the studies differ in terms of units of observation,[7] data frequency, sample period, and econometric method, they share a common objective: To estimate the impact on the spot market price paid to independent cattle feeders of an increase in non-cash purchases, expressed in terms of either the number of head slaughtered or the proportion of total slaughter attributable to non-cash purchases. More recent studies have gone a step further and attempted to estimate the relationship between spot market price and non-cash purchases simultaneously with relationships explaining packer's contemporaneous decisions to deliver forward contract, marketing agreement, or packer fed cattle to the packing plant (Ward, *et al.*).

In our judgment, what the literature has been able to provide so far is evidence of an empirical regularity that, using Schmalensee's language, is more useful in describing how the market *looks*, rather than explaining how it *works*. The empirical regularity is that the contemporaneous level of non-cash purchases, expressed either in absolute levels or as a proportion of slaughter, has a small, negative, and sometimes statistically significant relationship with spot market cattle prices.

What to make of the negative relationship depends on what the analyst posits as the economic mechanism behind it. Assuming, for the moment, that spot market cattle prices are competitively determined by the forces of supply and demand, one's first instinct is to think of the impact of non-cash purchases in terms of shifts in the short-run supply and demand curves for fed cattle. As outlined by Ward, *et al.*, non-cash procurement of cattle has the effect of shifting to the left both the supply and demand for fed cattle in the cash market. The shift in supply is due to reduced availability of cash cattle, and the shift in demand is caused by less aggressive bidding by packers who have assured some of their slaughter needs through non-cash purchases. But if a given increase in the volume of non-cash purchases were to shift spot market supply and demand by equal amounts, as seems plausible, the spot market price would be left unchanged. This leads some to attribute the observed negative correlation between spot price and the use of non-cash procurement methods to non-competitive pricing conduct on the part of packers. But Azzam (1998) has shown, using a model more sophisticated than the simple supply and demand analysis outlined above, that a negative contemporaneous relationship can emerge in a market characterized by competitive packer conduct as well.

In this report, we will first confirm, in section VII, that the negative correlation between the use of non-cash procurement methods and spot market price found by others using their data, is present in our data too. Then, in section VIII, we will suggest

[7]In some studies the unit of observation was the price of different pens of cattle; in others, the unit of observation was the average fed cattle price in major cattle feeding states.

economic mechanisms that might be responsible for these empirical relationships. In this effort, we will be very careful to distinguish between two kinds of relationships that are very different, both in their empirical manifestations and in their plausible economic causes: 1. The relationship between the relative degree of reliance on non-cash procurement methods by a given plant and the spot market prices paid by that plant *relative to the regional market's average price.* (studied in sections VII.1 and VIII.1), and 2. The relationship between the use of non-cash procurement methods at the regional level and the regional average spot market price (studied in sections VII.2 and VIII.2).

In section IX we investigate one particular institutional arrangement that might create the opportunity and incentive for abusive pricing conduct by packers. That possibility has to do with the nature of the base price in the formulas used to price marketing agreement cattle. In some cases, the base price for formula-priced cattle delivered this week is derived from the plant's average hot cost last week. Do we see evidence, in these cases, that packers attempt, through their spot market pricing conduct, to manipulate the formula base to their advantage?

Section X will summarize our findings on these issues and present our recommendations.

Before we can investigate these issues, however, some important questions about the determination of the volume and timing of deliveries of cattle procured by non-cash means, largely ignored in previous analyses, must be addressed. Who is responsible for deciding how many non-cash supply cattle will be delivered to the plant within any given time period? How far in advance of delivery is this determination made? The answers to these questions will be reflected in certain aspects of the econometric analysis presented in this report. The next section, section V, will provide an overview of the data and then address these key modeling issues.

Again, the report's main line of inquiry concerns the relationship between non-cash procurement methods and spot market price. As a preliminary to this main inquiry, section VI will use multiple regression analyses to conduct investigations of the differences between cattle purchased on the spot market, on the one hand, and cattle procured by each of the three non-cash procurement methods (marketing agreement, forward contract, and packer fed), on the other. Specifically, two questions will be addressed: Are there quality differences among cattle procured by different methods? And, are there quality-adjusted price differences among cattle procured by different methods?

V. DATA AND ASSUMPTIONS

The primary data set used in this study was collected by GIPSA. It provides a nearly complete record of cattle procurement activities for four large beef packing plants in the Texas panhandle region over the period from early February 1995 through mid-May 1996. The plants are the Excel plant at Friona, the Excel plant at Plainview, the IBP plant at Amarillo, and the Monfort plant at Cactus. The primary data set includes information on every lot of cattle, of over 35 head, purchased by the four Texas plants during the period of investigation. A complete listing of the types of information available for each of these lots is presented in Appendix A.

Certain parts of the analysis required supplementary data on regional average steer and heifer prices, boxed beef cutout values, Chicago Mercantile Exchange live cattle futures prices, and other variables. These were compiled, from standard published sources, either by GIPSA or by the authors of this report.

The three types of non-cash procurement methods (listed in decreasing order of importance for the four Texas plants) are marketing agreement cattle, forward contract cattle, and packer-fed cattle. Marketing agreement cattle were by far the largest non-cash source for the four Texas plants over the period of investigation. Tables V.1 and V.2 report the volumes of marketing agreement deliveries of steers and heifers, on a plant-by-plant basis, expressed as percentages of total non-cash purchases, and of total slaughter, respectively. As part of their investigation, GIPSA personnel interviewed feedyard owners and managers about various aspects of live cattle markets including the terms of their marketing agreements with packers. From our review of the reports of these interviews, the following assumptions seem warranted:

1. For the most part, the number of cattle to be delivered by a feeder, to a plant, under a given marketing agreement, within a given week, is determined by the feeder. In some cases, it appears that packers may occasionally amend the delivery numbers submitted by feeders.

2. The number of marketing agreement cattle to be delivered by a feeder within any one week is normally determined two weeks in advance of delivery.[8]

[8]In making the judgment that the volume of marketing agreement deliveries is "normally" determined two weeks in advance of delivery, we are relying on our interpretation of the company documents and interview reports summarized in Appendix B, not on the data. For marketing agreement lots, the data contain information about the "scheduling date," the date on which the packer decides the particular day of delivery, not the earlier "notification date," the date on which the feeder decides on the number of cattle to be delivered during a given week.

3. Once the volume of marketing agreement deliveries for a given week is set (normally by the feeder), the packer has discretion over the specific day or days of the week upon which delivery will be made.

Appendix B provides support for these assumptions in the form of several excerpts from company documents and from reports of interviews with feedyard personnel.

Forward contract cattle were the second most important non-cash source of steers and heifers for the four Texas plants. Again, Tables V.1 and V.2 show their significance, on a plant-by-plant basis, relative to total non-cash supply volume and to total slaughter. standard basis forward contract (which we assume to be typical of basis forward contracts used by other packers) stipulates that "The cattle shall be delivered *on a day designated by Buyer* during the delivery month, or by mutual agreement at an earlier or later date." (emphasis added) Anecdotal evidence suggests, however, that delivery timing is usually a mutual decision between the buyer and the feedlot, with an effort made to deliver cattle when their optimal potential is reached. We assume that the timing of forward contract cattle delivery is determined primarily by the packer. Once the decision to deliver is made, there can be a time lag attributable to delays in arranging for transportation. We assume that the number of forward contract cattle to be delivered in a given week is normally decided either one or two weeks in advance.[9]

Our data identifies lots of cattle purchased on forward contracts but contains no information on which lots were purchased on basis forward contracts and which (if any) were purchased on fixed price contracts. Certainly the vast majority (perhaps even all) of the forward contract cattle in the sample were purchased on basis forward contracts. Ward, *et al.* describe this type of contract form:

> "A packer bids a futures market basis for the month cattle are expected to reach slaughter weight and finish. The feeder then has the option of determining when

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[9]In making the judgment that the number of contract cattle to be delivered in a given week is "normally" determined one or two weeks in advance, we are relying on the data. For contract lots, the data usually contain the "scheduling date," the date on which the lot's delivery date is fixed by the packer. For these lots, the distribution of the number of days from the scheduling date until the kill date has a mean of 11.88 days and a standard deviation of 7.98 days. One possible scenario for a "typical" contract lot, therefore, is that it is scheduled on Monday of one week and delivered on Saturday of the following week, 12 days hence. More likely, however, the weeks of scheduling and delivery dates for a typical lot will not be consecutive but will be separated by an intervening week. One further complication: In some cases, the date recorded as "scheduling date" for contract cattle was actually the contract date because the scheduling date was not available. These cases were not identified in the data, nor can their identities be inferred with certainty.

> to price the cattle (i.e., select a futures market price). From that futures market price, a cash selling price is computed, based on the agreed-upon basis. . . . For example, assume that after the basis contract is signed, a cattle feeder believes the futures market price for the specified contract month has peaked. The cattle feeder notifies the packer and chooses the then-current futures market price, thereby also determining the cash sale price, based on the previously agreed basis bid."

The provision of the contract which covers price determination reads:

> "All basis price cattle shall be priced by Seller by notifying Buyer prior to the first day of the month of the live cattle futures price applicable to the transaction or the first day of the month the cattle are projected to finish, whichever is earlier, If Seller fails to set the futures price, Buyer will set the price on the last day of the pricing period by executing, or having the ability to execute, a trade within the closing trading range on the Chicago Mercantile Exchange (CME)."

Thus, by the time the delivery month arrives and the packer comes to the point of deciding how to allocate the contract's number of head across the delivery month's weeks, forward contract cattle represent a fixed-price supply source.

During the period of investigation, packer fed cattle were not used at all by constituted only a very small share of slaughter for the but did represent a significant percentage of all steers and heifers killed by (Table V.2) Obviously, the packer has complete discretion over when to utilize packer-owned supplies of cattle.

With these assumptions in mind, the analysis will proceed as follows. In section VII, we explore, in a manner similar to previous efforts, the empirical relationship between non-cash supplies and spot market prices at both the plant and regional levels. After that, in section VIII, we address the issue of what possible economic mechanisms could be behind the empirical relationships at both levels. Section IX addresses the influence of the base formula price on spot market pricing conduct. Section X summarizes the findings and offers some conclusions and recommendations.

VI. ARE THERE SYSTEMATIC DIFFERENCES AMONG CATTLE PROCURED BY DIFFERENT METHODS?

In this section, we make a preliminary investigation of the differences among cattle procured in different ways. In particular, we inquire as to whether cattle procured by the four different methods (spot market, contract, marketing agreement, and packer fed) display systematic differences in quality and in quality-adjusted price.[10] The answers to these questions are fundamental to an understanding of packers' incentives to use non-cash procurement methods. The quality issue, in particular, is of interest because of the wide-spread perception that cattle procured via marketing agreements, the largest non-cash procurement source in the GIPSA data, are of higher quality than spot market cattle.

VI.1. Quality Differences

There are several dimensions of the quality of a lot of fed cattle including yield, quality grade, yield grade, sex, and average carcass weight. Two other lot characteristics which can influence the price of the lot are the size of the lot (number of head) and the distance the lot must be shipped to the plant. One can get a preliminary idea of how these factors vary by procurement method by examining the summary statistics presented in Table VI.1.1. For each plant, and for each procurement method used by the plant during the sample period, the table reports the following statistics:

the total number of lots;
the proportions of steer lots, heifer lots, and mixed steer and heifer lots within this total;

and the sample mean and standard deviations of (variable name, units):

the number of cattle in the lot (HEAD, head);
the lot's total hot weight divided by total live weight (YIELD, %);
the percentage of cattle in the lot grading prime or choice (PCTPC, %);
the percentage of cattle in the lot achieving yield grades 1, 2, or 3 (PCTYG13, %);
the distance the cattle were shipped to the plant (MILES, miles);
and the lot's average carcass weight for steer, heifer, and mixed lots separately (lbs.).

A casual comparison of these statistics across procurement methods within a given plant supports the following generalizations:

> For all four plants, marketing agreement purchases contain a higher proportion of steer lots and have at least a slightly higher yield, on average, than lots procured by the other three methods.
>
> For all four plants, the indicator of yield grade (PCTYG13) varies relatively little on average, across procurement methods, but in three of the four plants the average value of PCTYG13 is higher for marketing agreement cattle than for the other procurement methods.

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[10]We are grateful to Professor DeeVon Bailey for suggesting that these analyses be incorporated in this report.

In the indicator of quality grade (PCTPC) is lower, on average, for marketing agreement cattle than for the other three procurement methods. In average quality grade is lower for contract cattle than for the other three procurement methods. In average quality grade is higher for spot cattle than for the other three methods. In there is little variation in quality grade across procurement methods.

In average carcass weight is higher for spot cattle than for contract and marketing agreement cattle. In average carcass weight is higher for marketing agreement and packer fed cattle than for spot and contract cattle. In average carcass weight is higher for marketing agreement cattle than for the other three sources; while in it is higher for packer fed cattle than for the other three procurement methods.

In the sample of packer fed lots appears to be more uniform in quality characteristics than the samples of lots procured by each of the other three methods. For this plant, the standard deviations of the distributions, across lots, of YIELD, PCTPC, PCTYG13, and average carcass weight for steer lots are all lower for the packer fed sample than for the spot, contract, and marketing agreement samples. It should be noted, however, that these summary statistics are based on only 15 packer fed lots slaughtered at the during the period of investigation. In the other three plants, it is often the sample of spot market lots that appears to be the most uniform. In the following cases (quality characteristic - plant) the standard deviation is lower for spot market lots then for each of the other procurement methods: PCTPC - PCTYG13 - average carcass weight in steer lots - average carcass weight in heifer lots - .[11]

When, as in this case, the "quality" of a commodity is multi-dimensional, one can construct a scalar index of quality through estimation of a function that explains price in terms of product characteristics.[12] In our application of this methodology, we start with

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[11]It should be emphasized that the standard deviations reported in Table VI.1.1 are indicative of the degree of dispersion in lot-average characteristics across lots. They do not measure the degree of dispersion in quality characteristics across cattle within a typical lot. The data set does not contain information on the uniformity of cattle within lots.

[12]This approach explains the market prices of a commodity with multiple quality characteristics in terms of the values of these characteristics. An example of this methodology is provided by Ladd and Martin.

the lots of live-weight priced fed cattle purchased on the spot market. For each plant, we perform an OLS regression of the prices of these lots on variables indicative of the lots' quality (like those summarized in Table VI.1.1) and a selection of other variables which may influence price (like the week of purchase). We then use the regression results to "evaluate," not only the live-weight-priced, spot-market-purchased lots that comprised the samples used for estimation, but also the lots of fed cattle procured by other means. A comparison of the evaluations across procurement methods provides one way to assess the "quality" of lots of fed cattle procured by alternative methods.

In more detail: For each plant separately, we use the sample of live-weight-priced, spot market fed cattle lots to estimate a price function. That is, we estimate a regression of the following form[13]:

$$\begin{aligned}
&PRICE_i = a_0 + a_1\, HEAD_i + a_2\, YIELD_i + a_3\, PCTPC_i + a_4\, PCTYG13_i + \\
&a_5\, MILES_i + a_6\, MILES2_i + a_7\, HEIFER_i + a_8\, MIX_i + a_9\, AWS_i + \qquad (1)\\
&a_{10}\, AW2S_i + a_{11}\, AWH_i + a_{12}\, AW2H_i + a_{13}\, AWM_i + a_{14}\, AW2M_i + a_{15}\, MON_i + \\
&a_{16}\, TUE_i + a_{17}\, WED_i + a_{18}\, THU_i + a_{19}\, WKEND_i + d_1\, PW1_i + d_2\, PW2_i + \ldots + \\
&d_{66}\, PW66_i + \varepsilon_i
\end{aligned}$$

where the "i" subscript indexes lots of cattle, ε_i represents the influence of factors not-otherwise-accounted-for (because they are not reflected in the data set), and the definitions of the variables in the regression are as follows:

PRICE =	the price of the lot of cattle measured in either one of two ways: the FOB feedyard price in \$/cwt. on a live-weight basis; or the "delivered hot cost," which represents acquisition cost plus transportation cost, in \$/cwt. on a carcass-weight basis.
HEAD =	number of cattle in the lot (head).
YIELD =	the lot's total hot weight divided by total live weight (%).
PCTPC =	percentage of the lot grading prime or choice (%).

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[13]The data set recorded 24,425 spot market purchases of lots of fed cattle by the four Texas plants combined. Only those lots that were priced on a live-weight basis were used in this analysis. Several other lots were dropped because of incomplete or obviously incorrect data. For example, approximately 800 lots had entries for total delivered cost (which should include transport cost) that were less than or equal to the entries for FOB feedyard cost (which should exclude transport cost). The price function regressions were run on a plant-by-plant basis with the following numbers of observations:

PCTYG13 = percentage of the lot achieving yield grades 1, 2, or 3 (%).

MILES = the distance the cattle were shipped to the plant (miles).

MILES2 = the square of the distance the cattle were shipped to the plant (miles^2).

HEIFER = a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.

MIXED = a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.

AWS = the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).

AW2S = the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^2).

AWH = the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).

AW2H = the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^2).

AWM = the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).

AW2M = the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^2).

MON = a dummy variable equal to 1 if the lot was purchased on a Monday, and equal to 0 otherwise.

TUE = a dummy variable equal to 1 if the lot was purchased on a Tuesday, and equal to 0 otherwise.

WED = a dummy variable equal to 1 if the lot was purchased on a Wednesday, and equal to 0 otherwise.

THU = a dummy variable equal to 1 if the lot was purchased on a Thursday, and equal to 0 otherwise.

WKEND = a dummy variable equal to 1 if the lot was purchased on a weekend, and equal to 0 otherwise.

PW1, PW2, . . ., PW66 = a set of dummy variables identifying the purchase weeks represented in the sample.

Tables VI.1.2 and VI.1.3 report the results of this regression, for each of the two definitions of the PRICE variable, in the case of The results for other plants, though not reported, were similar.

Denote the OLS estimates of the regression coefficients by $\hat{a}_0$, $\hat{a}_1$, $\hat{a}_2$, . . ., etc. For each of the lots of live-weight-priced, spot market cattle, we used the coefficient estimates to form an index of lot quality in the following manner:

$$\hat{PRICE}_i = \hat{a}_0 + \hat{a}_1 HEAD_i + \hat{a}_2 YIELD_i + \hat{a}_3 PCTPC_i + \hat{a}_4 PCTYG13_i + \hat{a}_5 MILES_i + \hat{a}_6 MILES2_i + \hat{a}_7 HEIFER_i + \hat{a}_8 MIX_i + \hat{a}_9 AWS_i + \hat{a}_{10} AW2S_i + \hat{a}_{11} AWH_i + \hat{a}_{12} AW2H_i + \hat{a}_{13} AWM_i + \hat{a}_{14} AW2M_i, \quad (2)$$

where $HEAD_i$, $YIELD_i$, . . ., etc., were the values of these variables for the i^{th} lot. Because the terms in the purchase-day-of-week and purchase-week-of-sample variables are omitted in the formula for $\hat{PRICE}$, the result is an estimate of the price that a lot of cattle with characteristics identical to those of the i^{th} lot, *would have brought* had it been sold on the spot market, on a live-weight-priced basis, on Friday (the "base" purchase day; that is, the one for which no dummy variable was included in the model) of the week of January 29, 1995 (the "base" purchase week). This estimate can be interpreted as a scalar index of lot "quality" that relies on the market's implicit evaluation of quality attributes, as reflected in the purchase price, but controls for any tendency for prices to vary, for reasons unrelated to quality, across days of the week or over weeks of the sample. The summary statistics for this index (mean, standard deviation, etc.) within the sample of live-weight-priced, spot market cattle, describe the distribution of quality among lots of cattle obtained by that particular procurement method.

The characteristics of a lot of cattle procured by another method (marketing agreement, contract, or packer fed) can also be substituted into equation (2) to obtain an estimate of the price that an otherwise-identical lot of cattle *would have brought* had it been sold on the spot market, on a live-weight-priced basis, on Friday of the week of January 29, 1995. The result; $\hat{PRICE}$ for a marketing agreement lot, say; is a lot "quality" index that is directly comparable to the $\hat{PRICE}$ quality indices for cattle that actually were purchased on the spot market. The summary statistics for the quality index within the samples of lots procured by other methods provide a representation of the overall quality of cattle obtained by those methods.

As mentioned above, for each plant, and for each definition of the dependent variable, a price regression of the form of equation (1) was estimated. The results were used to develop $\hat{PRICE}$ quality indices for every lot of fed cattle. The summary statistics for the distributions of these indices, within samples corresponding to a given procurement method, were then calculated and are reported in Table VI.1.4.

Overall, the results show evidence of relatively little systematic variation in average lot quality across procurement methods.[14] For example, based on the FOB feedyard price regression results, the mean of the quality index for marketing agreement cattle is slightly greater than the mean for spot market cattle in the plants; but this ordering is reversed in each of these cases when the quality index is based on the delivered hot cost regression results. Again using the FOB-feedyard-based quality index, spot market cattle appear to be of slightly higher quality than contract cattle in all four plants. But, in terms of the delivered-hot-cost-based index, contract cattle appear to be slightly better than spot cattle For both indices, the mean value for spot market lots exceeds the corresponding mean value for packer fed lots in But in one index suggests that spot market lots are of higher quality than packer-fed lots, and one suggests the opposite.

In the range between the minimum and maximum lot quality is greater among spot market lots than among contract, marketing agreement, or packer fed lots. Interestingly, however, the standard deviations of the distributions of quality among contract and marketing agreement lots are often greater than the standard deviation among spot market lots. This suggests that the samples of spot market lots typically contain more extreme quality "outliers" than do the samples corresponding to other procurement methods. But spot market lot quality does not appear to be more variable "on average" than contract or marketing agreement lot quality.

VI.2 Quality-adjusted Price Differences

Another issue of preliminary interest is whether the prices paid for lots of cattle procured by different methods appear to differ, once appropriate adjustments are made

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[14]It should be emphasized that, in this analysis, we are implicitly treating the size of the lot and the distance the lot is shipped to the plant as aspects of lot "quality." As Table VI.1.1 shows, these characteristics do have some tendency to vary systematically across procurement methods, and that variation contributes to differences in Table VI.1.4's procurement-method-specific means of the quality index through the market's implicit valuation of lot size and distance shipped. In using the product characteristic price function to evaluate lots, it is also possible to control for systematic variation in lot size and distance. Had we taken this approach, a comparison of the resulting quality index means would have been reflective of variation, across procurement methods, of the more conventional dimensions of "quality:" yield, quality grade, average carcass weight, etc.

for any systematic differences in quality.[15] Our strategy for investigating this issue is to carry out a multiple regression analysis of the sample of lots of fed cattle purchased by the four Texas plants during the investigation period. The dependent variable will be the price paid for each lot.[16] Independent variables will include a set of lot quality indicators, other factors which could conceivably influence price (such as the identity of the purchasing plant and the week of purchase) and a set of dummy variables which, for each plant separately, identify the procurement method. Estimates of the coefficients of these dummy variables should then reveal whether there are differences in "quality-adjusted price" across procurement methods.

In more detail: The dependent variable in the price regression is

DPRICE = the delivered hot-cost of the lot, which includes both acquisition and transport cost, on a carcass-weight basis ($/cwt).[17]

The menu of independent variables includes:

HEAD = number of cattle in the lot (head).
YIELD = the lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot grading prime or choice (%).
PCTYG13 = percentage of the lot achieving yield grades 1, 2, or 3 (%).
MILES = the distance the cattle were shipped to the plant (miles).
MILES2 = the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER = a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED = a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
CARCASS = a dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to 0 otherwise.
AWS = the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).

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[15]In this section's comparisons of prices across procurement methods, we make an effort to control for quality variation across lots even though the analysis based on the product characteristic approach in section VI.1 did not show clear evidence of systematic differences in quality among spot market, contract, and marketing agreement cattle.

[16]Packer fed cattle are excluded from this analysis because the "prices" reported for these lots are merely internal transfer prices that bear no necessary relation to observed market prices.

[17]Because no FOB feedyard prices were available for cattle procured by other than spot market means, it was necessary to base this regression on delivered price.

AW2S = the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).

AWH = the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).

AW2H = the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).

AWM = the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).

AW2M = the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

M a dummy variable equal to 1 if the lot was a marketing agreement purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

The list of independent variables also included a set of dummy variables identifying the week of the sample in which the lot was killed.[18]

The results of ordinary least squares estimation of this regression are reported in Table VI.2.1. Because we are primarily concerned at this stage with the possibility of quality-adjusted differences in price across procurement methods, our attention focuses on the estimates of the coefficients attaching to the dummy variables identifying

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[18]Because there is no definition of "purchase day" that is meaningful across lots of cattle procured by spot and non-spot means, purchase-day-of-week dummy variables could not be included in this regression.

procurement methods on a plant-by-plant basis.[19] The estimates of the coefficients of M , M , M , and M represent the differences in delivered hot costs between a marketing agreement lot of cattle and an otherwise identical lot purchased on the spot market by plants, respectively. These estimated quality-adjusted price differences are all significant, both statistically[20] and in terms of economic significance. The estimates of the premia paid to marketing agreement cattle range from a low of $0.52/cwt. to a high of $2.26/cwt. .[21] For comparison: The overall sample mean of delivered hot cost, the regression's dependent variable, is $102.12/cwt.

The estimates of the coefficients of C , C , C , and C represent the differences in delivered hot costs between a forward contract lot of cattle and an otherwise identical lot purchased on the spot market by the plants, respectively. The point estimate of the quality-adjusted price difference for is small in magnitude (-$0.01/cwt.) and statistically insignificant. The estimated price differences for the other three plants are all statistically significant at the 0.01% level and range from a low of $2.00/cwt. to a high of $2.46/cwt .[22]

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[19]The role of the other variables in this regression is to control for the price effects of variation in lot attributes other than procurement method. We will interpret estimates of the coefficients of these variables in our discussion of the results of similar regressions carried out elsewhere in this report.

[20]The estimates of the coefficients of are significantly different from zero at the 0.01% level.

[21]Actually, these estimates confound two separate effects: the "marketing agreement effect" and the "formula pricing effect." The data do not provide a capability to estimate these two effects separately because all marketing agreement cattle were priced on a (live-weight or carcass-weight) formula basis whereas all spot market cattle and virtually all forward contract cattle (99.3% of the lots) were priced on a (live-weight or carcass-weight) non-formula basis.

[22]The regression reported in Table VI.2.1 was also estimated on a plant-by-plant basis using the subsamples The table below reports the resulting estimates of the price premia paid to marketing agreement and forward contract cattle, relative to spot market cattle. There are some appreciable differences in magnitudes between these estimates and those obtained in the regression using the pooled data set. The one qualitative difference of note is that, judging by the results of the plant-by-plant regressions, appears to pay a quality-adjusted premium on forward contract cattle too.

These results suggest that the four Texas plants paid significant quality-adjusted price premia for marketing agreement cattle relative to cattle purchased on the spot market.[23] These estimated premia could be a reflection of the transaction cost savings experienced by packers when they employ marketing agreements. Or they could be an artifact of our inability to control for some potentially important cattle quality attributes, such as the uniformity of cattle within a lot.

Our results also suggest that three of the four plants paid significant quality-adjusted price premia for forward contract cattle relative to cattle purchased on the spot market.[24] It is possible that these apparent premia were simply due to futures contract performance which, during the period of investigation, happened to favor basis forward contract sellers over buyers. For example, if it were the case, over this relatively brief period, that futures market prices tended to overestimate spot prices at the contract expiration date, one would expect a corresponding tendency for prices of lots of forward contract cattle to exceed prices of lots of spot market cattle when compared across lots delivered the same week.

A careful investigation of this possibility is hampered by the fact that the data on lots of forward contract cattle do not include the basis bids, or the futures contract month, or the date on which the feeder priced the cattle, or even whether all contracts were basis forward contracts as opposed to fixed price contracts. A preliminary investigation can proceed, however, through reliance on some plausible guesses. We

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Variable	Estimate	t-statistic
M	1.565165	4.809
M	1.520932	15.173
M	1.706804	2.322
M	1.400933	2.876
C	1.678630	18.630
C	2.317293	22.837
C	2.665420	3.617
C	1.058751	2.166

[23]Our findings contrast quite sharply with those of Ward *et al.* Using a similar method but different data, they estimated the price premium paid to marketing agreement cattle to be on the order of only $0.07/cwt. to $0.10/cwt. (on a live-weight basis).

[24]This finding also contrasts sharply with the results reported in Ward *et al.* They found evidence that packers actually paid *lower* quality adjusted prices for forward contract cattle than for spot market cattle.

assume that all forward contract cattle were sold on basis forward contracts. We assume that lots of forward contract cattle that were delivered during weeks entirely within a futures contract month (February, April, June, August, October, and December), or a month preceding a futures contract month, were sold on contracts that tied sale price to the futures price for that month. Lots delivered in weeks that straddled the end of a futures contract month were assumed to have been sold on contracts tied to the price of the next futures contract.[25]

Given these assumptions, it is the performance of the February 1995 through June 1996 live cattle futures market contracts that is of relevance for this study. For each of these contracts, we considered the daily average price quotes on the contract for days from the first day of the contract month back through 120 days prior to that date.[26] We then took the difference between the average of these daily prices and the price on the first day of the contract month as a very rough estimate of the typical change in the futures price between the date of pricing of the forward contract cattle and the date of delivery. Finally we calculated a weighted average, across futures contracts, of these price differences with the weights taken to be the proportions of the sample's forward contract cattle assumed to be sold on contracts tied to each of the futures contracts.

The result of these calculations is a weighted average *decrease* in the futures price by $1.61/cwt. on a live-weight basis, the equivalent of roughly $2.56/cwt. on a carcass-weight basis. Subject to the validity of the many assumptions we have made, this result can be interpreted as the representative change in futures prices between the date when forward contract cattle were priced and the date when they were delivered. The fact that the figure is roughly equal to the estimated forward contract vs. spot quality-adjusted price differences estimated for three of the plants suggests a possible source of these "premia:" They may simply reflect the benefit forward contract sellers received as a result of futures contract prices that tended, on average, to overestimate future spot prices.

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[25]For example, lots delivered during weeks falling entirely within the months of May and June were assumed to be priced according to the price of the June futures contract. Lots delivered in a week including both June 30th and July 1st were assumed to be priced according to the price of the August futures contract.

[26]In the case of the February 1995 and April 1995 contracts, we went back only 29 days and 88 days, respectively, because earlier data were not readily available to us at the time this calculation was performed.

VII. WHAT IS THE EMPIRICAL RELATIONSHIP BETWEEN NON-CASH PURCHASES AND SPOT MARKET PRICES?

In this section, we investigate the empirical relationship, in the short run, between non-cash purchases of fed cattle and spot market cattle prices. In this regard, we draw a sharp distinction between two specific "levels" at which this relationship might be examined. We refer to the first as the "plant level" relationship. It is addressed in section VII.1 and pertains to the short-run relationship between non-cash purchases by a given plant and the spot market prices paid by that plant *relative to the regional market's average price*. We call the second "level" at which the relationship might be examined the "regional market level." It is addressed in section VII.2 and pertains to the short-run relationship between the use of non-cash cattle at the regional level and the regional average spot market price.

VII.1. The Empirical Relationship at the Plant Level

Evidence reviewed in section V suggests that packers have a fairly accurate idea of the volume of non-cash cattle deliveries they will receive over the near-term future. This is due to the fact that the packer has discretion over the scheduling of delivery of some types of non-cash purchases (forward contract and packer fed cattle) and to the fact that the non-cash cattle deliveries that are scheduled by feeders (marketing agreement cattle) require that a certain amount of advance notice be given to the packer. Thus, when a packer enters the spot market with the intention of purchasing cattle for slaughter over a given period of time; a given week, say; it typically knows the volume of non-cash cattle deliveries already scheduled for that week. For any given packer, moreover, this volume of pre-committed supplies tends to vary from week to week. The following graphical model shows how the packer's spot market cattle purchases and average spot market price is likely to vary in response to week to week fluctuations in the volume of non-cash cattle deliveries.

Figure 1 depicts the residual supply curve of spot market cattle facing an individual packer. Labeled AAC_S, for average acquisition cost of spot market cattle, this curve represents the regional spot market's overall supply net of spot cattle demands by other packers in the region. Defined in this way, the residual supply curve consists of the locus of price - quantity combinations available to the packer in its spot market dealings for the time period under consideration. The fact that the curve slopes upward reflects our assumption that the packer possesses at least some degree of market power in its regional spot cattle market: The price it must pay is not independent of the number of spot cattle it purchases. For given market conditions, purchasing a greater number of cattle requires that the packer bid more aggressively causing the average spot cattle acquisition cost to rise, at least slightly.[27] Of course, the position of the packer's residual supply curve can shift with shifts in regional supply or with changes in rival packers' spot marketing conduct for the period. Because residual supply, representing average cattle acquisition cost, is upward sloping, marginal cattle acquisition cost, also depicted in Figure 1 and labeled MAC_S, lies everywhere above it.

Figure 2 depicts the packer's marginal slaughter/processing cost for cattle, labeled MPC and drawn so as to indicate an approximately constant marginal processing cost out to plant "capacity" at which point marginal cost rises sharply. Figure 3 depicts the output demand curve, or average revenue curve (labeled AR), that the packer faces. As drawn here, with a slight downward slope, the packer is assumed to possess a small degree of output market power: If the packer were to sell more output, it would drive the price down slightly. If, instead, the packer's output price were independent of its sales, demand would be horizontal. Marginal revenue, denoted MR in Figure 3, lies everywhere below demand.[28]

Now consider a packer with a given volume of non-cash cattle deliveries already committed for the decision period. The acquisition cost of these cattle is already sunk and so will not affect the packer's spot market purchase decision. The packer's relevant marginal cost curve is therefore MPC alone, out to the pre-committed non-cash delivery volume, and is given by the vertical sum of MPC and MAC_S beyond that point. Figure 4 shows two such marginal cost curves, MC_1 and MC_2, corresponding to pre-committed non-cash supply volumes CS_1 and CS_2, respectively. In either case, the packer will purchase spot market cattle in numbers sufficient to bring total slaughter volume to the profit maximizing point at which MC = MR. With pre-committed supply volume CS_1, profits are maximized with total slaughter of TS_1 achieved with spot market purchases of $TS_1 - CS_1$. Alternatively, suppose that the packer entered the decision period with the larger volume of pre-committed supplies, CS_2, while the position of its residual spot market supply remains unchanged. Then optimal total slaughter would be TS_2, achieved with spot market purchases of $TS_2 - CS_2$. Because $TS_2 - CS_2$ is less than

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[27]A number of empirical studies have found evidence that packers possess at least some degree of "market power" in their cattle input markets. For an example, see Schroeter (1988). Again, this simply means that a typical individual packer perceives an upward sloping relationship between the number of spot market cattle procured, in any given time period, and the average acquisition cost of these cattle. We do not suggest that the existence of this market power is attributable, in any sense, to the use of non-cash procurement methods. Indeed, the Schroeter study found evidence of market power during a time period (1951-1983) in which the use of non-cash procurement methods was far less prevalent than it is now.

[28]The model's conclusions require that AAC_S and MAC_S slope upward and at least one of the following: MR slopes downward or MPC slopes upward at the equilibrium point.

TS_1 - CS_1, and because the packer's residual supply is upward sloping, the packer will pay a lower average price for spot market cattle with pre-committed deliveries CS_2 than with CS_1: For a given packer, *facing a given residual supply curve of spot market cattle*, higher volumes of pre-committed non-cash cattle deliveries will tend to be associated with lower prices paid on the spot market.

Notice the qualification emphasized with italics in the last sentence. Its importance can be seen by considering two simple examples. Suppose, on the one hand, that the scheduled non-cash cattle deliveries of all packers in the region were to increase by the same factor, say 20%, from one week to the next. The resulting drain on the number of cattle that would otherwise be available on the spot market would shift back the residual supply curves facing each packer. Thus, while each packer may well purchase fewer spot market cattle as a result of its increase in anticipated delivery numbers from non-cash sources, it is not obvious that they would be able to make those purchases at lower prices on average. Now, on the other hand, suppose that a given packer anticipates a 20% increase in non-cash cattle deliveries over last week's figures *and* that this increase will be offset by a reduction in the scheduled non-cash cattle deliveries to other packers in the regional market. In this case, one would expect little or no shift in the residual supply curve facing the packer anticipating increased non-cash deliveries. The analysis of the previous paragraph would apply and the packer with an increase in the scheduled volume of non-cash deliveries would purchase fewer spot market cattle at lower average prices than the previous week.

Consideration of the two scenarios described above suggests that prices paid on the spot market are actually a function of the packer's scheduled non-cash delivery volume *relative to rival packers' scheduled non-cash delivery volumes*. It is when a packer anticipates deliveries of non-cash cattle that are high relative to its rivals' degrees of reliance on non-cash supply sources for the same period that we might expect the packer to make spot market purchases at low prices. Moreover, "low prices," in this context, is also a relative concept. In any given week in any given regional spot market, there is in fact an entire distribution of prices paid for fed cattle; a distribution which shifts, from week to week, due to changes in market conditions. By a *low* price, we mean a price that is low relative to the mean of the price distribution representative of current market activity. These observations lead to the following hypothesis:

Hypothesis 1: Packers tend to pay spot market cattle prices that are "low" compared to the regional market's average price when they anticipate near-term- future deliveries of cattle from non-cash sources that are "high" relative to total slaughter volume and relative to rival packers' degrees of reliance on non-cash supply sources over the same period.

We will undertake an investigation of this hypothesized relationship between spot market prices paid and packers' scheduled non-cash delivery volumes using a multiple regression analysis of a data set with observations corresponding to individual spot market purchase lots. The dependent variable, RPRICE, is the "relative price" paid for the lot, defined as the price of the lot's cattle; on an FOB feedyard, live weight basis; minus the weighted average price of steers reported by AMS for the Oklahoma-Texas panhandle region on the day of purchase of the lot, in \$/cwt. Defined in this way, RPRICE can be interpreted as the lot's price's departure from a representative "average" price for the day of purchase.

The key explanatory variable will capture the effect on relative spot market prices of changes in the relative volume of scheduled deliveries of cattle from non-cash sources. To understand how this variable should be properly measured, some timing considerations must first be addressed. Again, when a packer purchases cattle on the spot market "today," it is with the intention of slaughtering those cattle over some future period, or "planning horizon." So, as argued using the graphical model presented above, spot prices paid today should be connected to the packer's relative degree of reliance on non-cash purchases over the planning horizon. Of course, there is no obvious and clear-cut way to define the planning horizon relevant to today's spot market pricing conduct for a given packer. We thought a reasonable approach to the problem would be to specify alternative plausible planning horizons and examine the nature and strength of the econometric relationship between spot cattle prices, on the one hand, and the relative degree of reliance on non-cash purchases during each of these planning horizons, on the other. So, in our analysis, the relative price of a lot of spot market cattle purchased today by a given plant will be explained in terms of that plant's relative degree of reliance on non-cash purchases over one of the following planning horizons.

Planning horizon 1: The starting and ending date of planning horizon 1 correspond, respectively, to the earliest kill date and the latest kill date for the lots of spot market cattle purchased by the plant today.[29]

Planning horizon 2: The period of seven days following today.

Planning horizon 3: The period of fourteen days following today.

The non-cash supply variable, which we call "relative ratio" and denote RRATIO, can then be defined in terms of any one of the three alternative planning horizons. But it remains to describe specifically how RRATIO is constructed. For each day on which spot market purchases were made, and for each packer, we first calculate the value of "RATIO," the proportion of total slaughter, over one of the three planning horizons, that

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[29]For , the earliest kill date for cattle purchased on a given day averaged 4.94 days after the purchase day. The latest kill date averaged 13.06 days after the purchase day. The corresponding figures for (4.64, 11.24), (4.07, 9.15), and (4.54, 9.49) were similar.

is attributable to non-cash purchases. Then, for each spot market lot purchased on that day, take the value of RRATIO to be the purchasing packer's value of RATIO expressed as a deviation from the average value of RATIO for the four Texas plants on that purchase day. For example, suppose that for a given spot market purchase day, the four plants' total slaughter volumes over the next seven days contained the following proportions of cattle from non-cash sources: 0.15, 0.30, 0.21, 0.38 for plants A, B, C, and D respectively. Then, using planning horizon 2 as the basis for definition, a lot purchased by plant A on that day would be assigned an RRATIO value of -0.11 (= 0.15 - (0.15 + 0.30 + 0.21 + 0.38)/4). With RRATIO defined in this way, a "high" ("low") value for a given lot means that the plant purchasing the lot anticipates a degree of reliance on non-cash purchases, over the planning horizon, that is "high" ("low") relative to that of its rivals.[30]

Besides RRATIO, additional explanatory variables were included to control for other sources of systematic variation in prices across plants and through time, and to account for the effects of a variety of lot "quality" indicators which may influence price. These additional variables are defined below.

HEAD =	number of cattle in the lot (head).
YIELD =	the lot's total hot weight divided by total live weight (%).
PCTPC =	percentage of the lot grading prime or choice (%).
PCTYG13 =	percentage of the lot achieving yield grades 1, 2, or 3 (%).
MILES =	the distance the cattle were shipped to the plant (miles).
MILES2 =	the square of the distance the cattle were shipped to the plant ($miles^2$).
HEIFER =	a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED =	a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
CARCASS =	a dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to zero if it was priced on a live-weight basis.
AWS =	the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).

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[30]Each of the four plants has a value of RRATIO for each of the spot market purchase days represented in the final sample. In the actual implementation of the estimation procedure, these values were normalized by subtracting the plant's sample average value for RRATIO. Because the menu of explanatory variables also includes plant-specific dummy variables, this normalization does not affect estimates of the coefficient of the RRATIO variable. As Table V.1 reveals, there were relatively significant differences among the plants in their overall degrees of reliance upon non-cash cattle, however. By normalizing RRATIO in this way, we load any price effects of cross-plant differences in the average propensity to use non-cash supplies, along with the effects of any not-otherwise-accounted-for plant-specific characteristics, onto the coefficients of the plant-specific dummy variables.

AW2S = the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).

AWH = the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).

AW2H = the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).

AWM = the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).

AW2M = the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the plant, and equal to 0 otherwise.

The list of explanatory variables also included dummy variables identifying the purchase-day-of-the-week (MON, TUE, WED, THU) and dummy variables identifying the purchase week of the sample.

The model was estimated by ordinary least squares.[31] The regression results for the case in which RRATIO is defined using planning horizon 1 are reported in Table VII.1.1. The results with respect to explanatory variables other than RRATIO are of secondary interest, so a discussion of these results is relegated to Appendix C.[32] The table below contains the point estimates, standard errors, and t-statistic values for the coefficient of RRATIO defined using each of the three planning horizons.

Planning horizon	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
1	-0.2149	0.0634	-3.391
2	-0.4133	0.0579	-7.141
3	-0.2224	0.0712	-3.125

[31]The original data set recorded 24,425 spot market purchases of lots of fed cattle by the four Texas plants combined. Of these, 2342 had to be deleted because the FOB feedyard price, which is required to determine the value of the model's dependent variable, was not recorded. Three lots were dropped because of missing or obviously incorrect data entries. An additional 812 were deleted because the recorded entry for the lot's total delivered cost (which should include transport cost) was less than or equal to the entry for FOB feedyard cost (which should exclude transport cost). While this inconsistency does not necessarily mean that the value for FOB feedyard price (FOB feedyard cost divided by the lot's total live weight) is in error, it at least casts some suspicion on its accuracy. To be usable in the analysis, lots had to have been purchased on days for which an AMS report of steer prices was available. As a practical matter, this restricted the sample to lots purchased on week days. Also, because the planning horizons are forward-looking, the sample does not contain information sufficient for the calculation of the value of RRATIO on some of the purchase days toward the end of the sample period: Lots purchased during the sample's last two weeks were dropped. These last two requirements led to the elimination of another 814 lots, bringing the usable total down to 20,454. Finally, the manner in which RRATIO is defined requires that attention be limited to the lots purchased on days on which all four plants registered spot market purchases. During the sample period, the Excel-Friona, Excel-Plainview, IBP, and Monfort plants made spot market purchases of fed cattle on 224, 214, 220, and 218 days, respectively. But there were only 148 days in the sample on which all four plants purchased on the spot market. Restricting attention to lots purchased on just these 148 days brings the sample to a final size of 17,853 observations.

[32]Estimates of the coefficients of the control variables were quite similar across models differing in the planning horizon used as the basis for definition of RRATIO. Appendix C also discusses the rationale for inclusion of each of the explanatory variables defined above.

Based on results from any one of the three regressions, the null hypothesis that the coefficient of RRATIO is zero can be rejected in favor of the one-sided alternative that it is negative at the 0.1% significance level. These findings are statistical evidence in support of hypothesis 1: When packers anticipate near-term-future deliveries of non-cash cattle that are "large" relative to total slaughter volume and relative to their rivals' degrees of reliance on non-cash purchases for the same period, they tend to pay spot market prices that are low relative to the market's current average price. We can base an estimate of the magnitude of the effect on the parameter estimates reported in the table above. Over the entire sample period, the proportion of the four plants' combined fed cattle slaughter that was attributable to non-cash purchases was approximately 0.29. Imagine that, from one week to the next, plant A experiences an increase in its near-term-future non-cash cattle proportion from 0.29 to 0.39 while, at the same time, there are offsetting changes in the use of non-cash purchases by the other plants. In this case, plant A's value of RRATIO would increase by 0.1. The parameter estimates suggest that the spot market price effects of this change would be a decrease of 0.021 to 0.041 \$/cwt. Thus, the magnitude of the effect is quite small.

It should be emphasized that the results of this analysis cannot be used to infer the likely effects of an across-the-board decrease in the degree of reliance on non-cash purchases. A uniform reduction in non-cash proportion by all four plants would leave values of the RRATIO variable unaffected. In this analysis, our objective was to determine whether a single plant's departure from the currently representative degree of reliance on non-cash purchases translates into a tendency to pay spot market prices that differ from average prices. What we have found is that when plants purchase spot market cattle for a planning horizon for which anticipated deliveries of non-cash cattle are "high" relative to their rivals' degrees of reliance on non-cash purchases, they tend, other things equal, to pay prices that are slightly below average.[33]

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[33]The coefficients associated with the plant dummy variables capture the not-otherwise-accounted-for price effects of plant-specific characteristics, including any price effects that may be attributable, in some way, to each plant's overall propensity to use non-cash procurement methods. We note that the ranking of plants, from the least to the most reliant on non-cash procurement methods is the same as the ranking of plants from the highest to the lowest estimated dummy variable coefficients:

of the fed cattle slaughtered over the period of investigation were attributable to non-cash procurement methods; dummy variable coefficient estimate =

was omitted from the regression)),

So, for example, once account is taken of all of the factors explicitly represented in the regression equation reported in Table VII.1.1,

However, we do not believe that this constitutes sufficient support for the conclusion that overall degree of reliance on non-cash procurement

VII.2 The Empirical Relationship at the Regional Level

Since some prior research has also investigated the relationship between the use of non-cash procurement methods and spot cattle prices at a more aggregate level, finding a negative relationship, we undertake similar regression analyses in order to see if the negative relationship is present in our data too. This leads to the following hypothesis:

> **Hypothesis 2: A multiple regression analysis of the relationship between a regional market's average spot cattle price (as the dependent variable) and the region's aggregate use of cattle from non-cash sources (as one of the independent variables) will reveal a negative relationship between the two, other things equal.**

To investigate the statistical relationship, in the short run, between average spot market cattle prices in the Texas panhandle region and the regional use of non-cash procurement methods, we use weekly data to regress price on the number of spot market cattle purchased by the four Texas plants, a measure of the packer's output price, a time trend, and a non-cash supply variable. The behavioral interpretation that seems most natural for such a regression is that of a packer demand curve for spot market cattle. As we shall see, however, ordinary least squares and two-stage least squares estimation fail to produce negative (much less, *significantly negative*) estimates of the coefficient of spot market quantity, as one would expect with a conventional downward sloping demand curve. We do not claim to have adequately characterized spot market demand with this formulation. Our objective in this exercise is merely to demonstrate that these data embody a statistical relationship between the contemporaneous values of regional price and non-cash supply usage similar to that found in other data sets using similar specifications: Spot market price tends to be low during weeks in which the use of cattle from non-cash sources is relatively high. The policy significance of this statistical relationship depends on the nature of the economic mechanism that is responsible for generating it. In the section VIII.2, we will propose and investigate an economic mechanism which may be the source of the empirical regularities revealed by the regression analysis carried out here.

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methods is the *cause* of its tendency to pay spot market prices that are "low" on average. Other plant-specific factors may be at work.

Specifically, we estimate regressions of the form of equation (3) using data for the 66 weeks of our sample:[34]

$$\text{average price in week } t = \gamma_0 + \gamma_1 \text{AVGVAL}_t + \gamma_2 Q_t + \gamma_3 (\text{non-cash supply deliveries in week } t) + \gamma_4 \text{WEEK}_t + \gamma_5 \text{WEEK2}_t + \varepsilon_t \qquad (3)$$

The dependent variable represents the region's average spot market cattle price in week *t* and is measured in each of the four ways to be described in detail below. AVGVAL_t is a measure of the price of the packer's output in week *t* calculated as follows: For each reporting day in week *t*, the AMS daily box beef cutout values (AMS LS411) for light choice, heavy choice, light select, and heavy select are averaged. These daily averages are themselves averaged over all reporting days in week *t* to obtain AVGVAL_t. Q_t is the number of steers and heifers purchased on the spot market by the four Texas plants in week *t*.[35] The terms in WEEK_t and WEEK2_t represent a quadratic time trend. WEEK_t is a simple time trend variable. (That is, WEEK_t equals 1 in week t = 1, equals 2 in week t = 2, etc.) And WEEK2_t is the square of WEEK_t. Finally, ε_t is a random error term.

The non-cash supply variable is measured in two different ways: by the total number of head of steers and heifers procured by non-cash methods (forward contract, marketing agreement, and packer fed) and delivered to the four Texas plants in week *t* (CSTOT_t), and by this number expressed as a proportion of the four plants' slaughter in week *t* (CSRAT_t).

Of the four alternative measures of the dependent variable, two, AVGSPR_t and AVGHPR_t, are defined using AMS reported prices. To construct the value of AVGSPR_t for a given week, start with the reported weighted average price of steers in the 1100-1250 lb. live weight category, in lots grading 35-65% select or choice, for the Oklahoma-Texas panhandle region, and the number of head upon which the reported price is based, for each reporting day in week *t* (AMS LS720). AVGSPR_t is then

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[34]The data set contains essentially complete records on the lots of cattle *killed* by the four Texas plants during a 67 week time span from the week of February 5, 1995, through the week of May 12, 1996. Information on the lots *purchased* during the last week of the sample was incomplete, however, so it had to be dropped in this analysis.

[35]Here we are implicitly assuming that the relevant regional market quantity is the number of fed cattle purchased by the four packing plants in our sample. To be sure, other plants make spot market purchases from feedyards in the Texas panhandle region. And the four plants in our sample occasionally ship cattle from feedyards hundreds of miles away. But it is probably safe to assume that the purchases of these plants is a good approximation for the trading volume in the relevant regional cattle market.

obtained as a head-weighted average of the daily average prices for reporting days in week *t*. The $AVGHPR_t$ series is similarly constructed, but starting with daily average heifer (1000-1150 lb., 35-65% SE/CH) prices (AMS LS720).

The other two measures of regional average price were constructed from price data for the four Texas plants in our sample. For each week *t*, $AVGCPR_t$ was calculated as a head-weighted average of the prices paid for spot market cattle (steers and heifers only, FOB feedyard, $/cwt. live weight basis) by the four Texas plants.

To motivate the construction of the final regional price series, $ADJCPR_t$, first consider that the $AVGSPR_t$ and $AVGHPR_t$ series arguably represent prices for a given quality of cattle through time.[36] $AVGCPR_t$, on the other hand, is based on prices paid for the cattle actually purchased by the four plants. If there were systematic variation, over time, in the quality of cattle purchased, the values of AVGCPR would not be comparable across weeks. Our fourth measure of regional average prices, $ADJCPR_t$, is the result of an effort to adjust the prices paid by the four Texas plants for possible week-to-week variation in spot market cattle quality.

The construction of the ADJCPR series begins with a regression equation explaining the price of spot market cattle (FOB feedyard, live weight basis) in terms of lot characteristics similar to those used in the price regression undertaken in section VII.1, and purchase week dummy variables. The results of this regression are presented in Table VII.2.1. Because this regression is quite similar to the one undertaken in section VII.1, we omit a detailed discussion of its results.

Now consider two lots of cattle with identical lot characteristics (number of head, yield, percentage grading prime or choice, etc.) but purchased in two different weeks of the sample period. The model predicts that these two lots would sell at prices that differ by the difference between their purchase week dummy variable coefficients. Thus, this difference is the model's estimate of the difference between the two weeks' prices for cattle of constant quality. Finally, to construct the adjusted price series, we set the value of $ADJCPR_t$ for the last week of the sample (the week of May 5, 1996) equal to the value of $AVGCPR_t$ for that week. We can think of the sample's last week as the "base" week, the one for which no purchase week dummy was included in the regression. To obtain the values of the $ADJCPR_t$ series for the remaining weeks of the sample, we start with its base week value and add the estimates of the coefficients of the purchase week dummy variables for each week. The result is a series of estimates

[36]The particular quality category; 35-65% select or choice, 1100 - 1250 lbs. (for steers) or 1000 - 1150 lbs. (for heifers); is quite broad, however, incorporating the majority of lots sold on the spot market.

of the prices at which the cattle representative of the sample's last week's spot market purchases would have sold in each of the other weeks of the sample period.[37]

The decision of which procedure to use in estimating equation (3) depends on properties of the error term, ε_t, representing not-otherwise-accounted-for factors influencing the determination of cattle price in the regional spot market. If the error term is uncorrelated with the equation's explanatory variables, ordinary least squares (OLS)

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[37]All four measures of regional price; AVGSPR, AVGHPR, AVGCPR, and ADJCPR; behaved very similarly in the regressions reported in this section and, as shown by the tables below, had very similar summary statistics and displayed very high simple correlation coefficients between all pairs of the price variables.

There are two points worth noting about the degree of similarity of these series. First, the AMS reported price series appear to be quite representative of the prices paid on the spot market, at least by the four plants in our data set. Second, there apparently was little or no systematic variation in spot market cattle quality over the sample period because the ADJCPR series, which adjusts prices for quality variation, is very similar to the AVGCPR series, which is merely an average of prices actually paid irrespective of quality.

Summary statistics for the four regional price variables:

	Mean	Std. dev.	Minimum	Maximum
AVGSPR	64.877	3.795	55.577	74.993
AVGHPR	64.883	3.802	55.548	75.000
AVGCPR	64.695	3.786	55.508	74.796
ADJCPR	64.763	3.784	55.599	74.901

Simple correlation coefficients among pairs of regional price variables:

	AVGHPR	AVGCPR	ADJCPR
AVGSPR	0.99979	0.99965	0.99932
AVGHPR		0.99953	0.99928
AVGCPR			0.99975

will produce consistent estimates.[38] On the other hand, if the error term is correlated with one or more explanatory variable. OLS estimates will be inconsistent and an instrumental variable technique, such as two-stage least squares (2SLS), should be used instead. In practice, the judgment about the presence of correlation between ε_t and explanatory variables is usually based more on theoretical considerations than on statistical tests.[39]

Correlation between the error term and explanatory variables in a regression equation arises when the explanatory variables are not *predetermined*; that is, when the value of the explanatory variable, in a given period, not only influences the contemporaneous value of the dependent variable but is, in turn, influenced by it. So we must consider whether each of the explanatory variables in equation (3) can safely be assumed to be predetermined or, instead, is likely to be simultaneously determined with the contemporaneous value of price.

Certainly the quadratic time trend terms are predetermined. (They might affect price in period *t* but are not affected by it.) Because the wholesale market for beef is national in scope, the price in this market, as proxied by AVGVAL, is probably relatively immune from the vagaries of cattle price in just one regional market. On this basis, we assume that AVGVAL is predetermined as well. We have argued in section V that the number of deliveries of non-cash cattle in week *t* are determined, by and large, in week *t* - 1 or earlier. Thus, while they conceivably might influence spot market price in period *t*, they would not be expected to be influenced by it.[40]

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[38]Loosely speaking, the property of "consistency" insures that the chances that the estimate of a parameter will err by more than any given amount will become vanishingly small as the size of the sample grows. Inconsistent estimators, on the other hand, can be subject to a systematic bias that does not vanish in the limit as sample size increases.

[39]There are statistical tests for correlation between the error term and explanatory variables in a regression equation. The most widely used such test is a version of Hausman's specification test. See Greene, section 16.8. The Hausman "exogeneity test" could be applied to determine whether the 2SLS estimates of equation (3) should be "favored" over the OLS estimates, or vice-versa. But that is not our objective here. We are merely interested in showing that regression analysis uncovers a statistically significant *ceteris paribus* negative relationship between spot market cattle prices and contemporaneous non-cash supply delivery volumes in weekly time series data, and that this finding is robust across estimation methods and definitions of the price and non-cash supply variables.

[40]It is distinctly possible, however, that non-cash cattle deliveries in week *t* are affected, not by price in week *t*, but by the expectation of week *t*'s price, formed in an earlier week. This possibility is specifically addressed in the analysis of section VIII.2.

That brings us to Q_t, the volume of cattle traded in the spot market in week *t*. On the one hand, it might be argued that the cattle reaching slaughter weight and finish in week *t* are perfectly inelastically supplied to the spot market; that is, are offered for immediate sale more-or-less regardless of price. Were this argument valid, Q_t could also be viewed as predetermined. On the other hand, it might be argued that feeders have an opportunity to shift cattle supplies from one week to another to take advantage of more favorable prices. In this event, Q_t and week *t*'s spot market price would be jointly determined, and Q_t would be correlated with the equation's error. These considerations lead us to undertake estimation of equation (3) using both ordinary least squares (OLS) and two-stage least squares (2SLS) and to compare the results of the two methods.[41]

Estimation of versions of equation (3) by OLS produced evidence of serial correlation in the error terms.[42] Consequently, equation (3) was estimated by the Yule-Walker procedure for correcting for errors of the first-order autoregressive (AR(1)) form.[43] Results are reported in Table VII.2.2 for a total of eight specifications: Each of the four dependent variables (AVGSPR, AVGHPR, AVGCPR, and ADJCPR) is employed with each of the two measures of non-cash supply deliveries (CSTOT and CSRAT).[44]

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[41]Actually, as will be explained presently, we estimate equation (3) by 2SLS and by the Yule-Walker procedure. The Yule-Walker procedure is an example of generalized least squares, or GLS. GLS amounts to OLS estimation of a transformed version of equation (3). The Yule-Walker procedure, in particular, entails a transformation that is appropriate for cases in which the error terms are serially correlated (ε_t and ε_s are correlated).

[42]For example, when CSTOT was used as the measure of non-cash supply deliveries, the values of the Durbin-Watson statistic were 0.726, 0.737, 0.725, and 0.741 for versions of the model with dependent variable AVGSPR, AVGHPR, AVGCPR, and ADJCPR respectively. Values such as these lead to rejection, at conventional significance levels, of the hypothesis of zero serial correlation in favor or the alternative of positive, first-order serial correlation. See Greene, section 13.5.1.

[43]The assumption of AR(1) errors appears to be an adequate characterization of the disturbance process: When the equations were re-estimated using the Yule-Walker procedure adapted to AR(2) errors, the regression parameter estimates differed little from those reported in Table VII.2.2 and the estimates of the second-order autoregressive parameters were invariably insignificant.

[44]The Table VII.2.2 estimates of "RHO" are those of the first-order autoregressive parameters in the specifications of the error process.

The possibility that Q_t may not be a predetermined variable in equation (3) (the possibility that Q_t and ε_t might be correlated) is accommodated by 2SLS estimation. This procedure essentially involves OLS estimation of a version of equation (3) in which Q_t, the explanatory variable suspected of being correlated with the error terms, is replaced by its projection on a set of "instrumental variables" that are more arguably uncorrelated with ε_t.[45] The results of 2SLS estimation of each of the model's eight versions are reported in Table VII.2.3.

One striking feature of the results reported in Tables VII.2.2 and VII.2.3 is the robustness of the findings with respect to the non-cash supply variable. In every case, the estimated coefficient of the volume of non-cash deliveries is significantly negative at the 1% level or better, especially when they are measured by the CSTOT variable. To get a feeling for the magnitude of the price effect of non-cash purchases, consider for example, the results obtained by the Yule-Walker procedure for the model with AVGSPR as the dependent variable (first two columns of Table VII.2.2). Suppose that the weekly volume of non-cash deliveries (CSTOT) were to increase from its mean value (about 26,400 head) by one sample standard deviation (about 7730 head). The estimation results, taken at face value, imply that the other-factors-held-fixed impact of this change would be a decrease in AVGSPR by \$0.69/cwt. If weekly non-cash cattle deliveries as a proportion of total weekly slaughter (CSRAT) were to increase from its mean value (about 0.29, or 29%) by one standard deviation (about 0.08, or 8%), the apparent other-factors-held-fixed effect would be a decrease in AVGSPR by \$0.54/cwt.[46] Relative to overall sample variability in price, the magnitude of this effect is "small." A \$0.60/cwt. change in the price of steers, for example, represents only about 16% of the 66-week sample standard deviation of steer prices and only about 3% of the range between the sample's minimum and maximum steer prices. On the other hand, a \$0.60/cwt. change in FOB feedyard prices would probably have a relatively significant impact on feeder profitability.

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[45]See Greene, section 16.5.2b. The instruments used for 2SLS estimation include AVGVAL, WEEK, WEEK2, one period lags of AVGVAL and Q, and current and one-period-lagged CSTOT, for those models with CSTOT as a regressor, or current and one-period-lagged CSRAT, for those models with CSRAT as a regressor.

[46]It is tempting to undertake similar calculations of the effect of non-cash purchases on price using the 2SLS estimation results. But if we really believe that regional price and quantity are jointly determined (the suspicion responsible for the decision to employ 2SLS estimation in the first place), it would be inappropriate to project the impact of a change in non-cash purchases on price *holding quantity constant*. The correct comparative static exercise in a simultaneous model would consider the impact of non-cash purchases on price and quantity jointly. This could only be done in the context of a complete model of price *and* quantity determination. We have not presented such a model here.

The regression results reported in Tables VII.2.2 and VII.2.3 support hypothesis 2 insofar as they uncover a particular empirical regularity between non-cash purchases and spot market price: Average price in the region's spot market for cattle tends to be relatively low in weeks in which delivery of cattle from non-cash sources are relatively high, other things equal. The policy relevance of this empirical regularity depends, however, on the nature of the economic mechanism responsible for generating it. In section VIII.2, we propose and investigate one particular intuitive model of the scheduling of non-cash deliveries which could account for the empirical relationships we have found in the data.

VIII. WHAT ECONOMIC MECHANISMS COULD BE BEHIND THE EMPIRICAL RELATIONSHIPS?

VIII.1. Price Discovery and the Distribution of Spot Market Transaction Prices

To interpret the results of the empirical analysis of section VII.1, one must distinguish between "price discovery" and "price determination." Following Ward:

> "Price determination is the interaction of the broad forces of supply and demand which determine the market price *level*. ... Price discovery is the process of buyers and sellers arriving at a transaction price for a given quality and quantity of a product at a given time and place, ... and begins with the market price level. Because buyers and sellers discover prices on the basis of uncertain expectations, transaction prices fluctuate around that market price level."

Consistent with this view, the price of fed cattle in any one regional market at any given date is characterized, not by a single point value, but by a distribution of values. The general location of the distribution, represented by its mean value, is determined, in Ward's words, "by the broad forces of supply and demand." But transaction prices on individual lots of cattle can depart from the regional average price for a variety of reasons.

First of all, individual lots of cattle can be priced above or below the market average price because of better or worse than average lot quality. This, of course, was the motivation for including several lot quality indicators among the explanatory variables in section VII.1's price regression. And, as is discussed in Appendix C, the estimation results for the coefficients of these quality indicators are generally consistent with the common-sense expectations that higher-than-average quality lots are rewarded with a premium and lower-than-average quality lots suffer a discount, relative to the regional average price. That is, within a given distribution of transaction prices, prices for cattle of "low" quality tend to fall on the left-hand-side of the distribution while prices for cattle of "high" quality tend to fall on the right-hand-side of the distribution, other things equal.

Transaction prices may differ, however, even across lots of cattle of given quality. On any given market day, competitive conditions may vary within the regional market. A feedyard in one part of the region may be visited by only one bidder and, consequently, receive relatively "low" bids. For feedyards, in other parts of the region, competition among two or three bidders may be the norm for that day, and bids may be higher as a result.

A packer enters the spot market intending to procure cattle for slaughter for a given planning horizon. The volume of deliveries of cattle from non-cash sources that the packer will receive over that horizon is known in advance. As the graphical model of section VII.1 shows, a packer who enters the spot market expecting a relatively "large" volume of cattle from non-cash sources to be delivered during the planning horizon, will seek to supplement these pre-committed supplies with relatively "few" spot market purchases. As long as the packer possesses some degree of market power in the spot market (that is; as long as the packer faces a spot market "residual" supply curve that is upward sloping), buying fewer spot market cattle will mean paying lower spot market prices, on average. On the other hand, a packer who enters the spot market expecting relatively few deliveries from non-cash sources in the near-term future, will seek to make relatively "many" spot market purchases. To do so, more aggressive bidding will be needed and average transaction prices will be correspondingly higher.

Consequently, one would expect that packers who enter the spot market with a "high" value of section VII.1's "RRATIO" variable will, other things equal, wind up paying prices below the mean of the transaction price distribution. Packers who have a "low" value for RRATIO will tend to procure cattle at prices above the mean of the distribution. This is the phenomenon reflected in the statistically significantly negative values of section VII.1's estimates of the coefficient of RRATIO. As noted there, however, the magnitude of this effect appears to be relatively small.

It should be emphasized that the finding of a significantly negative estimate for the coefficient of RRATIO does not mean that an across-the-board decrease in the degree of reliance on non-cash purchases would raise the average level of prices received by feeders who sell on the spot market. RRATIO measures a packer's degree of reliance on non-cash supplies *relative to* its rivals' degree of reliance on non-cash supplies: An across-the-board change in the average level of non-cash purchases would leave RRATIO unaffected. Instead, the results of the analysis tell us whether a single plant's departure from the currently representative degree of reliance on non-cash purchases translates into a tendency to pay spot market prices that differ from average prices. Our conclusion is that plants anticipating near-term future non-cash cattle deliveries that are "high" (relative to its rivals' degrees of reliance on non-cash cattle) tend to pay spot market prices that are slightly below average. Plants anticipating near-term future non-cash cattle deliveries that are relatively "low" tend to pay spot market prices that are slightly above average.

VIII.2. Price Expectations and the Scheduling of Deliveries of Non-cash Cattle

The analysis of section VII.1 has implications about how the spot market prices paid by packers with different degrees of reliance on non-cash purchases tend to compare with the mean of the price distribution. The crucial issue from the perspective of feeders who sell on the spot market is whether heavy use of non-cash procurement methods leads to a reduction in the mean price, shifting the entire distribution. Indeed, the analysis of section VII.2 did uncover a negative correlation, in weekly time series data, between the weekly volume of regional non-cash deliveries and the week's average spot market price for the region. But the question remains, is this negative correlation evidence of a causal relationship between the use of non-cash procurement methods and cash prices? In the remainder of this section, we describe and conduct preliminary tests of a model of non-cash cattle delivery scheduling decisions. This model explains how week-to-week fluctuations in the regional average spot market price, even if caused by factors completely unrelated to the region's use of non-cash procurement methods, could, nonetheless, account for the empirical regularity of the type uncovered in section VII.2.

Marketing agreements normally give feeders the right to determine the number of cattle delivered in a given week but require that they notify packers of this number typically two weeks in advance of actual delivery. Thus, in week *t* (say), feeders determine QM_{t+2}, the number of marketing agreement cattle they will deliver to packers during week $t + 2$. One important determinant of this number, of course, is the number of cattle, owned by feeders with marketing agreements, that are expected to reach optimal slaughter weight and finish during week $t + 2$. QM_{t+2} can differ from the number of cattle "ready" for market, however, if the current and expected future prices of cattle are such that feeders have a profit incentive to ship cattle slightly short of market weight or to slightly delay shipment of finished cattle. Price discounts for underweight or over-fat cattle limit the feeders' ability to benefit by choosing a delivery week other than the week cattle will be ready. But the price discount penalties are not severe for deliveries one week before or one week after the week in which cattle are ready.

Under conventional pricing formulas, marketing agreement cattle delivered in a given week will bring a price based, in one way or another, on spot market prices paid for cattle the previous week. So cattle delivered in week $t + 2$ would bring a price based on p_{t+1}, the spot market price paid for (non-formula) cattle in week $t + 1$. Marketing agreement cattle delivered in week $t + 3$ (scheduled in week $t + 1$) would bring a formula price based on week $t + 2$ spot prices. So if feeders, in week *t*, expect the week $t + 2$ price to be high relative to the week $t + 1$ price, they might postpone, for one week, the delivery of some of the cattle ready for week $t + 2$ delivery, so that they could instead be delivered in week *t* + 3. On the other hand, if the week *t* expectation of week *t* + 1's price is "high" relative to the expectation of week *t* + 2's price, we would expect feeders to schedule large deliveries in week *t* + 2 in order to take advantage of the favorable formula prices that are anticipated for week *t* + 2. For notational convenience, we will use the symbol $E_t[p_s]$ to denote the expectation, formed in week *t*, of the spot market price in a subsequent week, week *s*. Then the argument above can be summarized in the following way: Other things equal, QM_{t+2} should be positively correlated with $E_t[p_{t+1}]$ and negatively correlated with $E_t[p_{t+2}]$.

Contracts for forward sales of cattle typically reserve delivery scheduling rights for the packer. As with marketing agreement cattle, however, some time is required to arrange transportation to the plant once the packer has made the decision to call a given number of cattle under forward contract in a given week. As we explained in Chapter V, the data support the assumption that the number of contract cattle to be delivered in a given week are typically determined either one or two weeks in advance. Moreover, by the time the packer has reached the point of deciding when to schedule deliveries, forward contract cattle represent a fixed-price cattle supply source.

Assume, for the moment, that the volumes of contract cattle deliveries are determined two weeks in advance. The typical lag between purchase and delivery of spot market cattle is approximately one week or so. From the packer's point of view, forward contract cattle deliveries in week *t* + 2 substitute for spot market purchases in week *t* + 1.[47] Thus if packers, in week *t*, expected a high realization for week *t* + 1's spot price ($E_t[p_{t+1}]$ high), they would be inclined to schedule a large number of the fixed-price forward contract cattle for delivery in week *t* + 2. On the other hand, if packers, in week *t*, expect that the spot market price in week *t* + 2 will be high ($E_t[p_{t+2}]$ high), they would be inclined to hoard their limited inventory of fixed-price (forward contract) cattle, reserving them for delivery in week *t* + 3 when they can substitute for cattle that would otherwise have to be purchased on the spot market at a high price in week *t* + 2. Thus, just as with marketing agreement cattle deliveries, we would expect the number of forward contract cattle delivered in week *t* + 2, QC_{t+2}, to be positively correlated with $E_t[p_{t+1}]$ and negatively correlated with $E_t[p_{t+2}]$.

Two further details: First, for contract cattle, if the representative lag between scheduling and delivery is closer to one week than to two, a similar argument would establish that the volume of contract cattle delivered in week *t* + 2, say, should be positively correlated with p_{t+1} and negatively correlated with $E_{t+1}[p_{t+2}]$. Second, the forgoing argument; in the case of a two week lag between scheduling and delivery, for

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[47]We examined the distributions, for each plant in our sample, of the lag, in days, between purchase and delivery of spot market lots of fed cattle. For the

plants, respectively, the means (standard deviations) of these distributions were as follows:

example; might be interpreted to suggest that the key determinant of week *t* + *2* deliveries is the expectation of the *difference* between p_{t+2} and p_{t+1}, rather than the expectations of these two prices separately. This is a further hypothesis explored in our analysis.

We summarize our conjectures in the following two hypotheses:

Hypothesis 3A: The volume of marketing agreement cattle delivered in a given week; week *t* + *2*, say; tends, other things equal, to be positively correlated with the expectation, formed in week *t*, of the spot market price in week *t* + *1* and negatively correlated with the expectation; again, formed in week *t*; of the spot price in week *t* + *2*. The volume of forward contract cattle delivered in week *t* + *2* tends, other things equal, likewise to be positively correlated with $E_t[p_{t+1}]$ and negatively correlated with $E_t[p_{t+2}]$. Or, if the representative lag between scheduling and delivery of contract cattle is closer to one week than to two, the volume of contract cattle delivered in week *t* + *2* may tend, other things equal, to be positively correlated with p_{t+1} and negatively correlated with $E_{t+1}[p_{t+2}]$.

Hypothesis 3B: The volume of marketing agreement cattle delivered in a given week; week *t* + *2*, say; tends, other things equal, to be negatively correlated with $E_t[p_{t+2} - p_{t+1}]$. The volume of forward contract cattle delivered in week *t* + *2* tends, other things equal, likewise to be negatively correlated with $E_t[p_{t+2} - p_{t+1}]$. Or, if the representative lag between scheduling and delivery of contract cattle is closer to one week than to two, the volume of contract cattle delivered in week *t* + *2* may tend, other things equal, to be negatively correlated with $E_{t+1}[p_{t+2}] - p_{t+1}$.

To this point, our argument establishing a connection between price expectations and marketing agreement and contract delivery volumes is incomplete because it takes account only of the intertemporal arbitrage opportunities (the opportunities to achieve an incremental increase in net revenue by rescheduling delivery from one week to another) available to the decision makers who schedule the delivery of cattle procured by non-cash means, but ignores the arbitrage opportunities available to spot market sellers of cattle. It is important to consider these as well, especially in view of the fact that, for the four Texas plants over the period of investigation, the spot market was a considerably larger source of fed cattle than were non-cash procurement methods.[48]

Consider a spot market seller with cattle "ready" for market in week *t*. Selling the cattle "now" would bring the current spot market price, p_t, while deferring sale for one week would return an expected price of $E_t[p_{t+1}]$. If $E_t[p_{t+1}]$ were sufficiently larger than p_t, the spot market seller might, in fact, have an incentive to defer sale. This strategy would not be costless, however. The cattle would have to be fed for another week, the receipt of sales revenues would be postponed for another week, and, if the cattle were currently at optimal market weight and finish, they might suffer a slight price discount if their sale were postponed for a week. The magnitude of these arbitrage costs is affected by several factors. Some factors, like current feed prices and interest rates, are relatively "generic" in that they affect the arbitrage costs of all lots of cattle more-or-less equally. Other factors, like the current condition of the cattle and the availability of pen space at the feedyard where the cattle are fed, are "lot-specific" in that they affect arbitrage costs on a lot-by-lot basis. At any given point in time, therefore, the lots of cattle earmarked for spot market sale are characterized by a distribution of arbitrage costs.

Now assume that, in week *t*, an intertemporal arbitrage opportunity were to emerge, at least temporarily: $E_t[p_{t+1}] > p_t$, say. Spot market sellers would respond, starting with the lots that can be arbitraged at lowest cost, by withholding these lots from week *t's* spot market and deferring their sale for one week. This intertemporal reallocation will have the effect of driving p_t higher and driving $E_t[p_{t+1}]$ lower. As lots characterized by increasingly higher arbitrage costs were reallocated, p_t and $E_t[p_{t+1}]$ would move closer together until the profitable opportunities for intertemporal arbitrage were exhausted. At this point, the surviving gap between the current spot market price and the current expectation of next week's spot market price would be equal to the smallest arbitrage cost among the lots of cattle remaining among those supplied to the week *t* market.

A similar response would obtain if expected next week's price were sufficiently smaller than current price: $E_t[p_{t+1}] < p_t$, at least temporarily. In this case, starting with the lots subject to the smallest arbitrage cost, spot market cattle originally earmarked for sale in week *t + 1* would be intertemporally reallocated forward to week *t*, tending to drive p_t down and to drive $E_t[p_{t+1}]$ up. The arbitrage cost of this marketing strategy would typically result from the price discount suffered as a result of selling cattle short

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[48]Over the sample period, for the four plants combined, spot market purchases accounted for 71.29% of fed cattle slaughter. As the figures in Table V.2 imply, the plant-by-plant percentages of fed cattle slaughter attributable to spot market purchases were

of optimal market weight and finish. In the end, $E_t[p_{t+1}]$ and p_t would again be driven toward convergence up to marginal arbitrage cost.

The point is that, if we assume that emergent opportunities for intertemporal arbitrage are always fully exploited and, with their exploitation, they are ultimately eliminated, we can think of the surviving gap between this week's price and this week's expectation of next week's price as a reflection of marginal arbitrage cost, not only within the population of spot market lots, but within the population of lots earmarked for sale under marketing agreements or forward contracts as well. But, because spot market sales represent the predominant component of fed cattle marketings in the Texas Panhandle (accounting for over 70% of fed cattle slaughter by the four plants over the period of investigation) the shape and location of the distribution of arbitrage costs within the population of spot market lots will be the primary determinant of the gap between p_t and $E_t[p_{t+1}]$.

If the only factors affecting the arbitrage costs of lots of cattle were generic in nature, tending to affect arbitrage costs for all lots equally, the correlations described in Hypotheses 3A and 3B would not necessarily obtain. A "large" gap between the previous week's spot market price and a previously formed expectation of this week's spot price would mean that arbitrage costs for spot market cattle "ready" for sale tend to be "high." With only generic factors affecting arbitrage costs, this would mean correspondingly "high" arbitrage costs, on average, for marketing agreement cattle and forward contract cattle, leaving few profitable arbitrage opportunities available to the decision makers who schedule delivery of cattle from these sources. Since the arbitrage cost of a lot of cattle is also affected by lot-specific factors, however, the distributions of arbitrage costs for spot market cattle, marketing agreement cattle, and forward contract cattle do not move in lockstep. A "large" gap between the previous week's price and a previously formed expectation of this week's price, a reflection of generally high arbitrage costs within the population of spot market cattle "ready" for sale, will, in general, mean a "large" number of profitable arbitrage opportunities for the decision makers who schedule delivery of marketing agreement and forward contract cattle. Hypotheses 3A's and 3B's conjectured correlations between delivery volumes and actual and expected prices should be present in the data.

The "other things equal" qualifications in Hypotheses 3A and 3B are reminders that many other factors influence feeders' and packers' decisions about the number of non-cash cattle to deliver in a given week. For example, feeders' weekly marketing agreement delivery numbers will be heavily influenced by the number of cattle reaching optimal market potential each week. The amount of available pen space in the feedyard will also be a factor: When space is tight, feeders may be inclined to free up pen space by shipping marketing agreement cattle slightly short of optimal market finish, especially if there is an opportunity to purchase feeder cattle at a relatively low price. From a particular packer's point of view, the number of contract cattle to call in a given week depends, in large part, on the current inventory of contract cattle; that is, the total volume of cattle under contract for delivery at some time during the current month.

These packer- and feeder-idiosyncratic factors are important in delivery scheduling decisions, but are not reflected in our data set and, for the most part, can be proxied only highly imperfectly. So we will omit them from the regression analysis used to investigate the relationship between marketing agreement and contract deliveries and expected spot market prices.

The analysis will focus on the following regression equations:

$$QM_{t+2} = \delta_0 + \delta_1 E_t[p_{t+2}] + \delta_2 E_t[p_{t+1}] + \varepsilon_{t+2} \quad (4a)$$

$$QM_{t+2} = \gamma_0 + \gamma_1 E_t[p_{t+2} - p_{t+1}] + \eta_{t+2} \quad (4b)$$

$$QC_{t+2} = \delta_0 + \delta_1 E_t[p_{t+2}] + \delta_2 E_t[p_{t+1}] + \varepsilon_{t+2} \quad (5a)$$

$$QC_{t+2} = \gamma_0 + \gamma_1 E_t[p_{t+2} - p_{t+1}] + \eta_{t+2} \quad (5b)$$

$$QC_{t+2} = \delta_0 + \delta_1 E_{t+1}[p_{t+2}] + \delta_2 p_{t+1} + \varepsilon_{t+2} \quad (6a)$$

$$QC_{t+2} = \gamma_0 + \gamma_1 (E_{t+1}[p_{t+2}] - p_{t+1}) + \eta_{t+2} \quad (6b)$$

where QM_{t+2} (QC_{t+2}) is the number of head of marketing agreement (forward contract) cattle delivered (either to a given plant or to the four plants combined) in week *t + 2*. p_t represents week *t*'s average spot market price of steers in the Oklahoma-Texas panhandle region. $E_s[p_r]$, for various values of s and r, denotes the expectation, formed in week s, of week r's value of price. More will be said about these expectations in a moment. ε_{t+2} and η_{t+2} represent the effects of omitted variables that may influence non-cash cattle delivery volumes in week *t + 2*. With respect to the scheduling of marketing agreement deliveries, hypothesis 3A implies a negative value for δ_1 and a positive value for δ_2 in equation (4a). If, as hypothesis 3B suggests, the appropriate indicator of intertemporal arbitrage opportunities is the expected price *difference*, then one would expect a negative value for γ_1 in equation (4b). Because there is some ambiguity about the representative lag between scheduling and delivery in the case of forward contract cattle, we posit two sets of relations for QC_{t+2}. One, consisting of equations (5a) and (5b), pertains to a two week lag; the other, consisting of equations (6a) and (6b), is relevant to a one week lag. As in the case of marketing agreement cattle, hypothesis 3A implies a negative value for δ_1 and a positive value for δ_2 in equations (5a) and (6a). Hypothesis 3B implies a negative value for γ_1 in equations (5b) and (6b).

To carry out estimation of equations (4a), (4b), (5a), (5b), (6a), and (6b) we must first address the question of how decision makers will form their two-week-ahead ($E_t[p_{t+2}]$) and one-week-ahead ($E_t[p_{t+1}]$ or $E_{t+1}[p_{t+2}]$) forecasts of price and their two-week-ahead forecasts of the change in price ($E_t[p_{t+2} - p_{t+1}]$). One conventional modeling approach is to assume that the forecasts will be based on the information contained in a time series regression of the actual values of the variable to be forecast on a set of variables whose values are thought to be relevant to the determination of the forecast variable and were observable to decision makers in the week in which the forecast was formed. The series of fitted values from such regressions can be thought of as forecasts of price based on the information contained in the forecasting equation's explanatory variables. In the spirit of that conventional approach, we posit the following forecasting equations:

One-week-ahead price forecasting equation:

$$\begin{aligned} p_{t+1} = {} & a_0 + a_1\, p_t + a_2\, p_{t-1} + a_3\, \Delta fp_t + a_4\, val_t + a_5\, r_t \\ & + a_6\, cf_t + a_7\, fcp_t + a_8\, crnp_t \\ & + a_9\, cpl_t + a_{10} lcpl_t + \mu_{t+1} \end{aligned} \tag{7}$$

Two-week-ahead price forecasting equation:

$$\begin{aligned} p_{t+2} = {} & b_0 + b_1\, p_t + b_2\, p_{t-1} + b_3\, \Delta fp_t + b_4\, val_t + b_5\, r_t \\ & b_6\, cf_t + b_7\, fcp_t + b_8\, crnp_t \\ & + b_9\, cpl_t + b_{10} lcpl_t + \mu_{t+2} \end{aligned} \tag{8}$$

Two-week-ahead price difference forecasting equation:

$$\begin{aligned} p_{t+2} - p_{t+1} = {} & c_0 + c_1\, p_t + c_2\, p_{t-1} + c_3\, \Delta fp_t + c_4\, val_t + c_5\, r_t \\ & + c_6\, cf_t + c_7\, fcp_t + c_8\, crnp_t \\ & + c_9\, cpl_t + c_{10}\, lcpl_t + \mu_{t+2} \end{aligned} \tag{9}$$

where; for s = t - 1, t, t + 1, and t + 2; p_s is the region's average steer price in week *s*. Δfp_t is the change in the price of week *t*'s "nearby" Chicago Mercantile Exchange live cattle futures contract from the first reporting day of week *t - 1* to the first reporting day of week *t*. The "nearby contract" for week *t* is defined as the one associated with the first contract month to follow week *t*, assuming that the first day of the contract month is at least 7 days later than the first reporting day of week *t*. If the first day of a contract month is fewer than 7 days later, the next contract is taken as the "nearby contract." val_t is the average box beef cutout value for week *t*.[49] r_t is the 6-month Treasury bill rate

[49]This is exactly the same as the AVGVAL series defined and used in section VII.2.

on the Friday immediately prior to week t.[50] cf_t is the number of cattle (in thousands of head) on feed in week t in Texas feedyards with capacity of 1000 head or more. fcp_t is the price of feeder cattle (Oklahoma City; steers: medium #1, 600-650 lbs.) in week t in \$/cwt. $crnp_t$ is the price of feed corn (central Illinois; #2, yellow) in week t in \$/bu. cpl_t is the number of cattle (in thousands of head) placed on feed during week t in Texas feedyards with capacity of 1000 head or more. $lcpl_t$ is a simple average of the values of cpl_s for s values corresponding to weeks 15, 16, 17, and 18 weeks prior to week t. This variable is intended to provide a rough indication of the number of cattle that may be reaching market weight in feedyards serving the four Texas plants.[51] The μ_t terms in equations (7), (8), and (9) represent random errors.

Equations (7), (8), and (9) were first estimated by ordinary least squares (OLS) using 65, 64, and 64 weekly observations, respectively.[52] Each equation was tested for the presence of serial correlation in the error term (correlation between μ_t and μ_s for $t \neq s$). The hypothesis of no serial correlation in the errors could not be rejected in the case of equations (7) and (9), but was rejected at the 5% significance level in the case

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[50]The 6-month Treasury bill rate is included as a convenient proxy for the interest rates packers or feeders might face in the capital markets in which they secure financing for their operations. While the Treasury bill rate may not accurately reflect the *level* of the relevant capital market rates, the changes in the two rates are undoubtedly highly correlated.

[51]We could find only monthly (not weekly) data for the variables cf_t, fcp_t, $crnp_t$, cpl_t, and $lcpl_t$. In these cases, weekly estimates were constructed from monthly data using the following conventions. cf_t: The reported number of cattle on feed for the first day of a month was assigned to the week containing the month's first day. Linear interpolation was used to estimate cattle on feed during other weeks. fcp_t and $crnp_t$: Prices reported for the month were assigned to the week containing the 15^{th} day of the month. Linear interpolation was used to estimate prices for other weeks. cpl_t and $lcpl_t$: Weekly cattle placements were estimated based on the assumption that the number of placements for a given month was uniformly distributed across days of the month.

[52]The data set contains essentially complete records on the lots of cattle killed by the four Texas plants during a 67 week time span from the week of February 5, 1995 through the week of May 12, 1996. Because estimation of equations (7), (8), and (9) required lagged values, fewer than 67 observations were usable. Because equations (8) and (9) required one more lagged value of p_t than equation (7), the number of usable observations was one fewer in equations (8) and (9) than in equation (7).

of equation (8).[53] Ordinary least squares regression results for equations (7) and (9) are reported in Tables VIII.2.1 and VIII.2.2 respectively. In the analysis of equations (4a), (4b), (5a), (5b), (6a), and (6b), $E_t[p_{t+1}]$ was taken to be the series of fitted values from OLS estimation of equation (7). Shifting the values in this series forward one time period gives us our proxy for $E_{t+1}[p_{t+2}]$. $E_t[p_{t+2} - p_{t+1}]$ was taken to be the series of fitted values from OLS estimation of equation (9).

Evidence of serial correlation in the errors of equation (8) requires that this equation be estimated by a procedure other than OLS. The correction for serial correlation is complicated, somewhat, by the presence of lagged dependent variables (p_t and p_{t-1}) among the regressors. We use a feasible generalized least squares procedure suggested by Hatanaka.[54] In the first stage, p_t and p_{t-1} are regressed on a set of instrumental variables which, in our application, were taken to be the remaining explanatory variables in equation (8) plus an additional lag of each. In the second stage, a version of equation (8) was estimated by OLS, but with the fitted values from the first stage regressions, $\hat{p}_t$ and $\hat{p}_{t-1}$, replacing p_t and p_{t-1}. The residuals from this regression, denoted $\tilde{\mu}_{t+2}$, were recovered.[55] An autoregressive model with six lags (in our case) was estimated to obtain consistent estimates of the parameters of the μ_t process. In this regression, only the estimate of the second-order autoregressive parameter, $\tilde{\rho}_2$, was significantly different from zero at conventional levels.[56]

Using $\tilde{\rho}_2$, the consistent estimate of the second-order autoregressive parameter from the μ_{t+2} process, the data for equation (8) were filtered as follows:

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[53]Testing for serial correlation in the errors of these equations is complicated by the presence of lagged dependent variables (p_t and p_{t-1}) among the regressors. We used a testing procedure, suggested by Greene (section 13.5.3), that is a modification of the Breusch-Godfrey test. It involves regressing the residuals from OLS estimation on the original equation's explanatory variables and six (in our application) lags of the residuals. A standard F-test of the null hypothesis that the coefficients of the lagged residuals are all zero amounts to a test of no serial correlation (up to order six). The calculated F-statistics for equations (7), (8), and (9) were 0.707, 3.849, and 1.553, respectively. Compared to a 5% critical value of approximately 2.3, the results led to rejection of the null hypothesis (no serial correlation) in the case of equation (8) and failure to reject for equations (7) and (9).

[54]See Greene, section 13.7.2.

[55]In forming the residuals, the actual values of p_t and p_{t-1} were used instead of the fitted values from the first stage regressions.

[56] $\tilde{\rho}_2$ was significantly different from zero at the 3% level. None of the other autoregressive parameters were significantly different from zero at the 15% level.

$$p_{t+2}^* = p_{t+2} - \tilde{\rho}_2\, p_t,$$
$$p_t^* = p_t - \tilde{\rho}_2\, p_{t-2},$$
$$\Delta fp_t^* = \Delta fp_t - \tilde{\rho}_2\, \Delta fp_{t-2}, \ldots \text{ etc.}$$

In the final stage of the Hatanaka procedure, p_{t+2}^* is regressed on the "starred" versions of equation (8)'s explanatory variables and on $\tilde{\mu}_t$, the twice-lagged residual from the second stage regression. The resulting estimates of the regression parameters, $\hat{b}_0$, $\hat{b}_1$, $\hat{b}_2$, . . ., etc., are consistent estimates of the parameters of equation (8). An updated estimate of the second-order autoregression parameter, $\hat{\rho}_2$, is formed by adding the estimate of the coefficient of $\tilde{\mu}_t$ to $\tilde{\rho}_2$. Table VIII.2.3 reports these estimates.

Developing consistent forecasts based on a model with serially correlated errors requires that information contained in lagged residuals be taken into account in forming the forecast. For the two-week-ahead forecast of price required for the analysis of equations (4a), (4b), (5a), (5b), (6a), and (6b) we take

$$E_t[p_{t+2}] = \hat{b}_0 + \hat{b}_1\, p_t + \ldots + \hat{b}_{10}\, lcpl_t + \hat{\rho}_2\, \hat{\mu}_t.$$

Notice that all of the terms on the right-hand-side, including $\hat{\mu}_t$, are in the week *t* information set, as required.[57]

Having used forecasting equations (7), (8), and (9) to develop proxies for the expectations, equations (4a), (4b), (5a), (5b), (6a), and (6b) were estimated by ordinary least squares using 62 week of data.[58] Results are reported in Tables VIII.2.4, VIII.2.5, VIII.2.6, and VIII.2.7. The t-statistics reported in those tables are based on

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[57]In forming these forecasts, we take $\hat{\mu}_t$ to be the residual from equation (8) based on the parameter estimates obtained in the final stage of the Hatanaka procedure, not the $\tilde{\mu}_t$ residual obtained in an earlier stage. The squared simple correlation coefficient between the two-week-ahead forecast series formed in this manner and the actual price series was 0.7502.

[58]The requirement of additional lagged values in the Hatanaka method used to estimate equation (8) led to the loss of additional observations.

heteroscedasticity and autocorrelation consistent standard errors calculated using the Newey-West procedure.[59]

Hypothesis 3A, as it applies to marketing agreement cattle, implies a negative value for δ_1 and a positive value for δ_2 in equation (4a). The estimation results for equation (4a), reported in Table VIII.2.4, show that, in all cases (for each of the four plants separately, and for the four plants combined) the signs of the point estimates of δ_1 and δ_2 are consistent with the hypothesis. Moreover, in all cases except the coefficient estimates are significantly different from zero (in a one-tailed test) at the 1% level.

When we test hypothesis 3A as it applies to forward contract cattle, we are limited to just two cases: forward contract deliveries to , and to the four plants combined. Deliveries of contract cattle to plants were sufficiently infrequent as to leave, in each of those cases, a significant number of weeks of the sample with zero total delivery volume.[60] Moreover, in the case of forward contract cattle, the implications of hypothesis 3A are not as sharp as they are for marketing agreement cattle because of the ambiguity with respect to the length of the representative interval between the scheduling of contract cattle and their delivery: two weeks or one week. If two weeks is the appropriate interval, the argument supporting hypothesis 3A implies that δ_1 should be negative and δ_2 should be positive in equation (5a). If one week is more typical, we should find the same sign pattern in equation (6a).

Results of estimation of equations (5a) and (6a) are reported in Table VIII.2.6. Once again, the signs of the point estimates of the coefficients of price expectations are consistent with the hypothesis in all cases, although statistical significance is generally lacking. The results are stronger for the four-plant-combined regression than for the

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[59]See Greene, section 13.4.3. The Newey-West procedure produces consistent estimates of OLS standard errors that are robust with respect to heteroscedasticity and autocorrelation of unspecified form.

[60]The 62-week sample proportions of zero observations for the QC_{t+2} series were An entirely defensible method of estimating equations (5a), (5b), (6a), or (6b) for any one of the plants individually would require the use of a limited dependent variable procedure such as Tobit. See Greene, section 20.3.2. That kind of exercise was not undertaken here because of the difficulties of generating heteroscedasticity and autocorrelation robust standard errors (*a la* Newey and West) in the context of Tobit estimation.

regression, particularly in the case of equation (6a).[61] For that case, the estimate of δ_1 is significantly negative at the 10% level and the estimate of δ_2 is significantly positive at the 5% level.

Hypothesis 3B addresses the possibility that the key determinant of week *t* + 2 deliveries may be an expectation of a price change, rather than the expectations of the two prices separately. As it applies to marketing agreement cattle, hypothesis 3B can be tested within the context of regression equation (4b). Estimation results are reported in Table VIII.2.5. There is limited support for hypothesis 3B, which implies that γ_1, the coefficient of $E_t[p_{t+2} - p_{t+1}]$, should be negative. In all but one case the estimated value of γ_1 is negative, but significance is generally lacking. The estimates are significantly negative in regression (at the 5% level) and in the four-plant-combined regression (at the 10% level). When applied to forward contract cattle deliveries, hypothesis 3B receives stronger support, as is evident in the regression results presented in Table VIII.2.7. For the four-plant-combined case, the estimates of γ_1 are significantly negative at the 5% level in both equation (5b), which assumes a two week representative interval between scheduling and delivery, and equation (6b), which is based on the assumption of a one week interval.

To summarize, in the case of marketing agreement cattle, the largest non-cash supply source of cattle for the four Texas plants during the period of investigation, hypothesis 3A finds strong support in three of the four individual plant-level analyses and in the four-plant-combined analysis. Hypothesis 3B, on the other hand, receives, at best, only limited support. In our judgment, these findings are strongly supportive of the general notion that marketing agreement feeders' delivery scheduling decisions are related to their expectations of future spot market prices in the manner in which we have suggested. We also offered the further conjecture that the delivery scheduling decision rule may, in fact, rely on the summary measure of future market conditions given by the expected *change* in price between next week and the week after next, rather than on the expected *levels* of these two prices separately. There is only minimal support for this additional conjecture.[62]

In the case of forward contract cattle, tests of hypotheses 3A and 3B are complicated by the ambiguity about the length of the typical interval between delivery

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[61]Keep in mind that the results of estimation of the versions of equations (5a), (5b), (6a), and (6b), should, perhaps, be discounted to a degree because of our failure to properly account for the limited dependent variable problem.

[62]So, in fact, an expected spot price change of \$0.20/cwt, say, may have a different influence on feeders plans for delivery under marketing agreements depending on the current level of spot price.

scheduling and delivery.[63] Nevertheless, for the forward contract cattle case, hypothesis 3A finds weak support in the results of estimation of the four-plant-combined version of equation (6a) (which assumes a one week interval between scheduling and delivery). Hypothesis 3B finds moderate support in the four-plant-combined regressions based on equations (5b) (assuming a 2 week interval) and (6b) (assuming a one week interval).

As mentioned earlier, several important feeder- and packer-specific factors affecting the scheduling of marketing agreement and forward contract deliveries were omitted from the regression models of equations (4a), (4b), (5a), (5b), (6a), and (6b) because data were unavailable. This undoubtedly accounts for the fact that the overall explanatory power of these regressions is quite low, as is evidenced by the R^2 values that are reported in Tables VIII.2.4, VIII.2.5, VIII.2.6, and VIII.2.7. Nonetheless, we interpret the results of the regression analysis as providing support for the intuitive model of non-cash supply delivery scheduling that underlies hypotheses 3A and 3B:[64] Other things equal, weekly marketing agreement and forward contract deliveries tend to be positively correlated with a previously-formed expectation of last week's price and negatively correlated with a previously-formed expectation of this week's price.

Packers and feeders make week-to-week decisions about the scheduling of forward contract and marketing agreement cattle deliveries. To a large extent, these decisions are driven by a desire to slaughter cattle when their optimum biological potential is reached. But there is some capability for intertemporal shifting of deliveries in response to economic considerations dictated by changing spot market prices. In particular, we have argued that the incentives confronting feeders and packers will lead, other things equal, to "high" deliveries of marketing agreement and forward contract cattle in weeks in which the *ex ante* expectation of the spot market price is "low."[65] But because the experienced market participants who make the scheduling decisions are undoubtedly quite good forecasters of price (at least over a relatively short forecast horizon, such as one or two weeks), their *ex ante* expectations are likely to be quite highly correlated with the *ex post* realizations of price. So the tendency for weekly deliveries from non-cash supply sources to be negatively correlated with the

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[63]Tests of hypotheses 3A and 3B are further complicated by the limited dependent variable problem that plagues each of the plant-level analyses, but especially in the cases of . See the discussion in footnote 60.

[64]This support is strong in the case of the quantitatively most significant non-cash supply source: marketing agreement cattle. But there is also some limited support for the model in the case of forward contract cattle.

[65]The regression analysis of this section has uncovered some empirical regularities in the data that are consistent with this conjecture.

unobserved *ex ante* price expectations could well manifest itself in a negative correlation between weekly non-cash deliveries and the observed *ex post* realizations of price. This, of course, is exactly the kind of empirical relationship between delivery volumes for non-cash cattle and spot market cattle prices revealed by the analysis of section VII.2.

This line of reasoning counsels caution in the interpretation of the empirical findings of section VII.2. As those findings demonstrate, the data reveal a tendency for spot market cattle prices to be "low," other things equal, in weeks in which deliveries of cattle procured by non-cash means are "high." But this empirical regularity does not necessarily mean that there is an underlying mechanism whereby large deliveries of non-cash cattle in a particular week *cause* that week's spot market price to fall. Even if week-to-week fluctuations in the spot cattle price in a regional market were generated essentially independently of the region's deliveries of non-cash cattle,[66] the incentives that influence the delivery scheduling decisions of feeders and packers would still result in a negative correlation between observed spot price and slaughter of cattle procured by non-cash methods in weekly time series data.

Our point is that an observed negative correlation between non-cash cattle deliveries and spot market prices is not necessarily evidence of abusive market conduct on the part of packers who utilize non-cash procurement methods. We have argued this point with what might be called a *partial* analysis rather than an *equilibrium* analysis insofar as we have specifically addressed only the effect that intertemporal fluctuations in the spot market price would have on packers' and feeders' non-cash cattle delivery scheduling decisions; but not how or whether those delivery scheduling decisions would feed-back into spot market price determination. This partial approach was motivated by the observation that the spot market remains the dominant source of fed cattle, accounting for about 71% of fed cattle slaughter in the GIPSA data. The largest non-cash source, marketing agreements, is responsible for 21% of fed cattle slaughter. Our simplified, "partial," approach is implicitly based on the assumption that spot market transaction volume and price are jointly determined in each period; the resulting price (or, rather, the expectations thereof), in turn, influence non-cash delivery schedules; which then have only negligible feedback into spot market price determination.

Providing a complete, coherent equilibrium analysis is beyond the scope of this report, but we can offer a preliminary sketch of the ideas such a model would incorporate. Packers' and feeders' non-cash cattle delivery scheduling decisions tend to have a mirror image in packers' decisions about how many spot market cattle to purchase in a given week For example, if in week *t*, $E_t[p_{t+1}]$ is "high" and $E_t[p_{t+2}]$ is "low," the incentives we have described will lead to "high" deliveries of both marketing agreement and forward contract cattle in week *t* + 2. With a relatively large supply

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[66]For example, one can imagine a hypothetical possibility in which regional market spot prices are determined primarily by broader, national market factors.

precommitted for week $t + 2$, packers will desire to purchase "few" spot market cattle in week $t + 1$ (for delivery in week $t + 2$), with this easing of demand having the tendency to reduce the spot market price in week $t + 1$. Thus, it would appear that the intertemporal shifting of non-cash cattle deliveries, and the accommodating intertemporal pattern of spot market demand, might simply serve to attenuate cycles in the spot market price: When a confluence of exogenous factors leads to week t expectations of a "high" price in week $t + 1$, non-cash cattle deliveries will substitute, to some extent, for spot cattle purchases and the anticipated peak in spot prices will turn out to be rather lower than if these substitution possibilities had not been available. (As we have noted in the text of the report, the actions of spot market sellers to exploit the intertemporal arbitrage opportunities available to them also work to "smooth-out" price cycles.) While this is merely a preliminary sketch of how our informal model might be extended to allow for feedback from non-cash cattle delivery scheduling decisions to spot market price determination, it does not appear that the extension would alter our findings appreciably.

IX. DOES THE FORMULA BASE PRICE INFLUENCE SPOT MARKET PRICING CONDUCT?

What we have accomplished up to this point is to demonstrate that the data exhibit a negative relationship between the delivery volumes of cattle procured by non-cash methods and spot cattle prices, but that this negative relationship does not necessarily mean that higher levels of non-cash cattle usage will cause lower spot market cattle prices. By the same token, the negative relationship is not necessarily evidence of "abusive" conduct by packers. To investigate the possibility of abusive or "manipulative" behavior by packers, one must carefully examine the market's institutional arrangements for situations in which the packer would have the opportunity and incentive to engage in such behavior. One conjecture, sometimes put forward by producers, is that packers' spot market pricing conduct is used to manipulate their marketing agreement pricing formula base to their advantage. That is the conjecture examined in this section.

For the four Texas plants during the period of investigation, all cattle delivered under marketing agreements were priced by formulas. The use of formulas, moreover, was reserved almost exclusively for marketing agreement cattle.[67] Generally speaking, formulas involve a base price, that applies to cattle of given quality characteristics (typically defined in terms of a given yield grade, quality grade, and carcass weight

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[67] purchased 13 lots of forward contract cattle on a formula basis. All other lots of spot market and forward contract cattle, for all plants, were priced on a non-formula carcass or live weight basis.

range), and a system of premia and discounts that are used to adjust the base price when delivered cattle characteristics deviate from those of the base carcass. The following table reports the formulas represented in the data and the number of lots purchased under each during the period of investigation.[68]

Packer	Formula	Number of lots
Excel	567	
Excel	Peterson	
Excel	Dimmit	
IBP	Pioneer	
IBP	Cactus	
Monfort	Southern	
Monfort	Original	
Monfort	Caprock	
Monfort	Lubbock	

One important distinction among formulas has to do with whether the base price is derived from a USDA reported price, or from some sort of average price paid by the packer for non-formula cattle in the recent past. For example, the base price for the formula is the weekly weighted average price for steers and heifers, in lots grading 35% - 65% choice, from the USDA Texas-Oklahoma Weekly Average Report (AMS LS721) for the week prior to the week in which the formula-priced cattle are killed. The formulas also use base prices derived from various USDA reported prices the week prior to the kill. The base prices of the remaining formulas are not derived from USDA data, however. The formulas use base prices derived from the weekly average delivered hot cost of non-formula cattle slaughtered at the during the week in which the formula cattle are killed. Thus the cattle establishing the average hot cost for a given week are, for the most part, spot market cattle purchased the previous week. The base prices of the

[68]The formula results in a price to be applied on a live weight basis. All of the others result in carcass weight prices.

formulas are similarly derived except that, in these cases, the weekly average hot cost is an average taken over cattle slaughtered at the [69]

Although feeders determine the week in which marketing agreement cattle will be delivered, packers typically have two weeks advance notice of the volume of scheduled deliveries. When a packer anticipates an unusually large volume of marketing agreement deliveries in a given week, there is an obvious incentive to try to reduce the formula's base price so as to reduce the price that will have to be paid for the formula-priced cattle. When the base price is derived from USDA reported prices, however, there would appear to be little, if any, capability on the part of the packer to manipulate a formula base. When the base price is derived from a one- or two-plant average hot cost, on the other hand, the possibility exists that packers might manipulate the base through strategic conduct in their spot-market (non-formula) purchases the previous week. To see what form such strategic conduct might take, we must examine the base price derivation in a little more detail.

Consider the formula, for example. Again, like all formulas, consists of a base price relevant to a carcass of specific characteristics (the "base carcass") and a system of premia and discounts that are set to adjust the base price when delivered cattle deviate from base carcass characteristics. The derivation of the base price is a quite complicated procedure but its essential features can be summarized as follows. Start with the weekly average delivered hot cost (in the of non-formula cattle slaughtered during the week in which the formula cattle are killed. For the most part, these cattle were purchased during the previous week. Using the premium/discount schedule, calculate a weighted-average premium/discount, called a "grading spread," for the cattle used in the average hot cost calculation. If the week's non-formula cattle graded superior to the base carcass, on average, the grading spread will be positive; if they graded inferior to the base carcass, on average, the grading spread will be negative. This grading spread is then subtracted from the average delivered hot cost to obtain the base price. [70]

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[69]Notice, at this point, that the base prices for the formulas are not set *equal to* the weekly average hot costs; they are merely *derived from* them. Additional detail concerning base price derivations will be introduced presently.

[70]One document we have seen on the formula describes the base price as the average hot cost *plus* the grading spread. This description merely embodies the alternative sign convention in its interpretation of "grading spread." In this alternative interpretation, the grading spread is positive for cattle grading inferior to the base carcass; negative for cattle grading better than the base carcass.

Now suppose, for example, that a lot of formula cattle is of quality exactly comparable, on average, to that of the week's non-formula cattle. The premium/discount calculated for this lot, when added to the base price, would exactly offset the grading spread so that the lot would be paid, on a delivered price per cwt. carcass basis, exactly the week's average delivered hot cost. Lots grading superior to the weighted average quality of the week's non-formula cattle would be paid more than average delivered hot cost; lots grading inferior to average quality would be paid less.

The base price of the formula is similarly derived. The mechanics of the base price derivations for the formulas are quite different, but the effect is the same in the following sense: Formula lots "compete" against the plant's weekly average quality of non-formula cattle. Lots that beat the plant average quality will receive a premium relative to average hot cost of non-formula cattle; lots inferior to plant average quality will sustain a discount.

The practical significance of these methods of base price calculation is as follows: Even when the base price is derived from plant average hot cost (as with the), a packer cannot manipulate the base price simply by purchasing cattle that are inferior relative to the spot market's average quality. Purchasing inferior cattle would reduce average hot cost. But it would also result in a negative grading spread which would offset the hot cost reduction leaving the formula base price approximately unchanged. It is conceivable, however, that a packer could strategically reduce its formula base price by paying lower spot market prices for cattle *of given quality*. Doing so would require that the packer's buyer's bid less aggressively than usual which, of course, would mean that they would succeed in purchasing fewer spot market cattle. Keep in mind, however, that the weeks in which manipulation of the formula base is most appealing (those in which anticipated marketing agreement deliveries are high) are precisely the weeks in which fewer spot market cattle will be needed.

These considerations lead us to Hypothesis 4:

Hypothesis 4: The relationship between marketing agreement cattle deliveries and spot market prices may differ depending upon the type of base price used in the pricing formula. In particular, when the pricing formula is based on the plant's average hot cost, there might be a tendency for the plant to pay relatively low spot prices in a week preceding a week in which a relatively large volume of marketing agreement cattle are delivered. When the pricing formula is based on a USDA reported price, any such tendency may be weaker or non-existent.

To investigate this hypothesis, we need to examine the relationship between the cash prices paid on the spot market for cattle slaughtered each week in a given plant (or firm) and the plant's (or firm's) weekly volume of deliveries under specific marketing agreements. If we find that weekly relative spot market (non-formula) prices are negatively correlated with weekly marketing agreement deliveries, but only for those marketing agreements with a base price derived from plant hot cost, it would represent evidence of the type of formula base price manipulation suggested by the preceding discussion. Notice that it is the correlation between marketing agreement deliveries and *relative* prices that matters. So in our analysis, we must adjust prices for week-to-week variation in the general cattle price level, and for lot-to-lot variation in cattle quality.

To do this, we begin with a linear multiple regression explaining prices; on a delivered, hot cost basis; as a function of quality characteristics and kill week dummy variables. The sample consists of all spot market lots of fed cattle purchased by the four plants during the sample period.[71] The dependent variable is the lot's total delivered cost divided by carcass weight, in $/cwt. A set of kill week dummies are included to allow for a different intercept for each kill week. Additional explanatory variables include the size of the lot in head; the lot's yield; the percentage of the lot grading prime and choice combined; the distance cattle were shipped to the plant in miles; the percentage of the lot achieving yield grades 1, 2, or 3; separate dummy variables for lots of heifers and for mixed lots of heifers and steers; a dummy variable for lots on which the cash price was quoted on a carcass- (as opposed to live-) weight basis; the lot's average carcass weight in pounds; the square of the lot's average carcass weight; and dummy variables for the purchase day-of-the-week. The results of ordinary least squares (OLS) estimation of this regression equation are reported in Table IX.1. Because this regression is auxiliary to the main inquiry, we relegate a detailed discussion of its results to Appendix D. In what follows, we refer to this regression as the "price regression."

Now consider the residuals from the price regression, the portion of the delivered hot cost of each lot unexplained by the model's independent variables. Because the price regression model allows for a different intercept for each kill week, the OLS residuals for any given kill week will average zero, when averaged across all four plants. A given kill week's residuals for a single plant need not average zero, however. In fact, the average residual for a given plant and for a given kill week provides an indication of the relative prices paid by that plant for spot market cattle slaughtered during that kill week. If the plant's average residual is positive for a given week, it means that the plant's spot market prices for cattle killed that week were "above the market," on a quality adjusted basis. A negative average residual would indicate that the plant purchased cattle killed during the week at quality-adjusted spot market prices that were "below the market," on average.

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[71]Weekend purchases were excluded.

It remains to investigate the correlation between these plant-specific series of weekly average residuals with the weekly volumes of cattle deliveries under specific marketing agreements.[72] One way to do this is with a simple regression of the average residuals on marketing agreement deliveries. Therefore, we use ordinary least squares to estimate a series of regressions of the following form:

$$RES_t = \alpha + \beta M_t + \varepsilon_t, \qquad (10)$$

where RES_t is the head-weighted-average residual from the price regression, for a given plant for week t, and M_t is the volume of cattle delivered to the plant in week t under marketing agreements using specific pricing formulas. M_t is measured either by the number of head or as a proportion of the week's total slaughter. Data consist of observations for the 67 weeks of the sample for which we have complete information from the four Texas plants. Attention focuses primarily on the algebraic sign and the statistical significance of the estimates of the β parameters. These are reported in Table IX.2.

Once again, the formula base price manipulation strategy proposed in this discussion would manifest itself in a finding of significantly negative estimates of β, but only for those regressions in which the marketing agreement deliveries are priced by formulas using the packer's average hot cost to determine the base ( ). There is no such pattern clearly evident in the results reported in Table IX.2. The estimate of β is negative with a marginal significance level of 6.3% in a one-tailed test (t-statistic = -1.529) in the regression when marketing agreement deliveries are measured in head. But the regressions also yield negative point estimates with even lower marginal significance levels, even though the base prices are derived from USDA reported figures. The regressions produce negative point estimates of β as well. But here the one-tailed test marginal significance levels are no lower than 10% (t-statistics = -1.124 and -1.278). Consequently, we can not say that these regression results lend support to hypothesis 4. That is, the results do not support the claim that packers try to manipulate formula base prices through their pricing strategies in spot market purchases.

[72]Actually the analysis is based, not on a simple average of a plant's residuals for each week, but on a weighted average wherein each lot's residual receives a weight equal to the number of head in the lot.

X. FINDINGS AND RECOMMENDATIONS

X.1. Summary of Findings

The main purpose of this research was to investigate the relationship between the use of non-cash methods for procuring fed cattle and the prices packers pay for fed cattle on the spot market. The nature of the data dictated that that investigation be limited to an examination of what we have called "short-run" issues; issues concerning the pattern of week-to-week covariation between spot market prices, on the one hand, and the delivery volumes of cattle procured by non-cash means, on the other. "Long-run" questions; questions about the changes in overall market conditions that one might expect to observe if the use of non-cash procurement methods were banned or severely restricted; are not thoroughly examined.[73] Before undertaking this main inquiry, we addressed two related preliminary questions: Are there quality differences among fed cattle procured by different methods? And, are there quality-adjusted price differences among cattle procured by different methods?

To investigate the possibility of systematic differences in cattle quality across procurement methods, we first compared summary statistics for the distributions of lot-quality indicators (like yield, percentage of the lot grading prime and choice, etc.) across procurement methods. Some generalizations are supported by the results of this comparison. For example, it appears that marketing agreement purchases tend to include a higher proportion of all-steer lots and tend to have at least a slightly higher yield, on average, than lots procured by the other three methods (spot market, forward contract, and packer fed). Other potentially interesting quality comparisons could not be made due to data limitations. For example, we have no basis for determining whether the quality-uniformity of cattle *within a lot* tends to vary systematically across procurement methods.

Because the "quality" of a lot of fed cattle is multi-dimensional, we also used the product characteristic approach to develop summary, dollar-value, indices of the quality of lots procured by various methods. For a given lot, the resulting price index amounts to a forecast of the price that a lot with identical quality characteristics would have brought had it been sold on the spot market, on a live-weight-priced basis, on a given day. As such, it is directly comparable to the values of the index for other lots: Lots of higher quality should have a higher price index. Overall, the results of this analysis

[73]Our investigation of short-run questions does, however, shed light on the credibility of a commonly-made claim regarding a long-run concern; namely, the claim that a negative correlation between non-cash cattle deliveries and spot prices in weekly data means that restricting the use of non-cash procurement methods will lead to higher spot prices on average.

show evidence of relatively little variation in average lot quality across procurement methods.

The second preliminary question concerned the possibility that there may be quality-adjusted price differences across procurement methods. To address this question, we undertook a multiple regression analysis of lot price (delivered hot cost) as a function of lot quality indicators; other factors which could conceivably influence price, such as the identity of the purchasing plant and the week of purchase; and a set of dummy variables which, for each plant separately, identify the procurement method. From the estimates of the coefficients of these dummy variables, one can infer the differences, in delivered hot cost, between otherwise-identical lots procured by different methods. The results show that each of the four plants pays quality-adjusted, delivered-price "premia" on marketing agreement lots, relative to spot market lots, with the point estimates of these premia ranging from

on a carcass-weight basis. The

also appear to pay quality-adjusted, delivered-price premia on forward contract lots, with point estimates of these premia on the order of \$2.00 to \$2.50/cwt. on a carcass-weight basis.[74]

Again, this report's main purpose was to investigate the short-run relationship between the use of non-cash procurement methods and spot market prices for fed cattle. We began this inquiry by attempting to characterize the empirical relationship. Specifically, we addressed two questions: 1. What is the empirical relationship, over time, between the relative degree of reliance on non-cash supply sources by a given plant and the spot market prices that that plant pays *relative to the regional average spot price of fed cattle?* and 2. What is the empirical relationship between the overall use of non-cash procurement methods by packers in a given region and the regional spot market's average price? Bearing in mind that any given regional spot market for cattle, at any given point in time, is characterized, not by a single price, but by a *distribution* of prices at which transactions occur, these questions can be rephrased in the following ways: 1. How does a packing plant's degree of reliance on non-cash procurement methods affect the spot prices it pays within the current distribution of transactions prices? and 2. How is the overall use of non-cash supplies by packers in a given region related to the position of the regional spot market's distribution of transaction prices?

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[74]In the case of marketing agreement cattle, these estimated price premia may be reflections of the value to the packer of the transaction cost savings of the use of marketing agreements. Or they may be statistical artifacts due to our inability to control for some lot quality aspects, such as the degree of uniformity of cattle within a lot. In the case of forward contract cattle, there is some tentative evidence to suggest that the premia are attributable to futures market performance that, over the period of investigation, happened to favor basis forward contract sellers over buyers.

Regarding the first question, we find that plants that currently have a higher than average degree of reliance on non-cash procurement methods tend to make spot market purchases at prices slightly below the mean of the distribution, all else equal. Regression results suggest that, for a ten percentage point increase in the non-cash supply proportion of near-term future slaughter, a plant's spot market prices fall by somewhere in the vicinity of \$0.02/cwt. to \$0.04/cwt. But this does not mean that the use of non-cash procurement methods leads to lower prices received, on average, by feeders who sell cattle on the spot market. The regression results are simply a reflection of the relationship between individual lot transaction prices and the mean of the distribution of transaction prices *given the observed position of the overall distribution*. In other words, the regression results have implications only about the "identities" of packers who happen to buy at "low-end" prices and those who buy at "high-end" prices: Other things equal, packers that currently have a "high" relative degree of reliance on non-cash supplies tend to pay slightly lower-than-average prices while packers that currently have a "low" relative degree of reliance on non-cash procurement methods tend to pay slightly higher-than-average prices. Even if there were no cattle procured via non-cash methods, there would still be a distribution of spot market transaction prices with, at any given point in time, some packers paying above average prices and some paying below average prices. It is conceivable, however, that the use of non-cash supplies, as one source of heterogeneity among packers, may have an effect on the dispersion of the transaction price distribution. The implications of such an effect for packer, feeder, and consumer welfare is an entirely separate issue.

Non-cash procurement methods would pose a potential threat to feeder welfare if their use were responsible for a decrease in the average spot market price, thus shifting the entire distribution of transaction prices. This brings us to the second question relating regional use of non-cash procurement methods and regional average price. Previous studies have uncovered a tendency for regional spot prices to be "low" during periods in which regional deliveries of non-cash supplies are "high." Some suspect that this is evidence of a causal relationship enabling packers to depress spot prices at will merely by increasing their utilization of non-cash procurement methods. As we show, using a variety of price and non-cash supply measures, and alternative statistical procedures, the negative relationship, in the short run, between regional use of non-cash cattle and regional average spot prices is present in our data too. The policy relevance of this empirical finding depends on the nature of the economic mechanism that is responsible for it.

We propose, and subject to preliminary testing, one specific underlying mechanism to explain the observed negative relationship between deliveries of non-cash cattle and spot market prices. Our hypothesis is that the observed empirical regularity is attributable to the incentives confronting the decision-makers responsible for scheduling the delivery of marketing agreement and forward contract cattle.

Marketing agreements normally give feeders the right to determine the number of cattle delivered in a given week. We have argued that feeders have an incentive to schedule a "high" volume of marketing agreement cattle deliveries in a week for which the *ex ante*, two-week-ahead forecast of price was "low." Contracts for forward sales of cattle, on the other hand, typically reserve delivery scheduling rights for the packer. Here too, we have argued that it is in the interest of packers to schedule a "high" volume of contract cattle deliveries in weeks for which a one- (or two-) week-ahead price forecast was "low." Our analysis of the data produced some evidence that actual decisions on the timing of delivery of non-cash cattle do, in fact, respond to these incentives, especially in the case of marketing agreement cattle, the most significant non-cash supply source for the four Texas plants over the period of investigation.

So there is reason to expect that marketing agreement and forward contract deliveries will be negatively correlated with unobserved *ex ante* forecasts of spot market price. But if the decision-makers have good forecasting ability, this correlation could manifest itself in a negative correlation between marketing agreement and forward contract deliveries and the observed *ex post* realizations of price. This, of course, is exactly the kind of empirical relationship between the volume of deliveries of non-cash cattle and spot market prices found, at the regional level, in this and other studies.

This summarizes our hypothesis about the economic mechanism responsible for the empirical regularity of a negative relationship between the use of non-cash procurement methods and spot prices at the regional level. We conclude that

> **. . . the tendency for spot market cattle prices to be "low," other things equal, in weeks in which non-cash cattle deliveries are "high," does not necessarily mean that there is an underlying mechanism whereby large deliveries of non-cash cattle in a particular week *cause* that week's spot market price to fall. Even if week-to-week fluctuations in the spot cattle price in a regional market were generated essentially independently of the region's use of non-cash supply sources, the incentives that influence the delivery scheduling decisions of feeders and packers would still result in a negative correlation between observed spot price and non-cash cattle slaughter in weekly time series data.**

Up to this point, the analysis has established that there is a negative relationship between the use of non-cash procurement methods and spot market cattle prices, but that this negative relationship does not necessarily mean that higher levels of non-cash cattle deliveries will cause lower spot prices. By the same token, the results of the analysis do not absolve packers of noncompetitive conduct. To investigate the possibility of abusive conduct, one must carefully examine the market's institutional arrangements for situations in which the packer would have the opportunity and incentive to engage in such behavior. One conjecture, sometimes put forward by cattle feeders, is that packers' spot market pricing conduct is used to manipulate their marketing agreement pricing formula base to their advantage.

Although feeders determine the number of marketing agreement cattle to be delivered to a packer in any one week, packers typically have two weeks advance notice of the volume of scheduled deliveries. When a packer anticipates an unusually large volume of marketing agreement deliveries in a given week, it has an incentive to try to reduce the pricing formula's base price so as to reduce the price that will have to be paid for the marketing agreement cattle. When the base price is derived from a USDA reported price, however, there would appear to be little, if any, capability on the part of the packer to manipulate the formula base. When the base price is derived from a one- or two-plant average hot cost, on the other hand, the possibility exists that the packer might manipulate the base through strategic conduct in its spot market (non-formula) purchases the previous week. In particular, when the pricing formula is based on the plant's average hot cost, there might be a tendency for the plant to pay relatively low spot prices in a week preceding a week in which a relatively large volume of marketing agreement cattle are delivered. When the pricing formula is based on a USDA reported price, any such tendency may be weaker or non-existent. So we examined the relationship between relative spot prices (this week) and the (next week's) volume of marketing agreement deliveries, for both cases: deliveries priced by a formula with a base derived from a USDA report, and deliveries priced by a formula with a base derived from plant hot cost. We found that

> **. . . the econometric results do not lend support to the hypothesis that packers try to manipulate formula base prices through their pricing strategies in spot market purchases.**

X.2 Recommendations

In light of our results, we recommend that the agency should not rely on the statistical finding of a negative correlation between deliveries of cattle procured by non-cash methods and spot market prices as evidence of intent by packers to depress cattle prices through the use of non-cash supply sources, or as evidence of the unintentional consequence of lower prices as a result of non-cash supply use. The agency should be cognizant, however, that certain pricing mechanisms may be more conducive to noncompetitive conduct than others. For example, it stands to reason that when the formula base price is derived from an "in-house" average hot cost rather than a USDA reported price, there is a potential for manipulation of the formula base through spot market pricing conduct. We make this cautionary note in spite of the fact that we found no clear evidence of such abuse in the Texas panhandle data. Also, should the trend toward increased use of non-cash procurement methods continue, thus further thinning the spot market, spot prices will become increasingly less reflective of the forces of supply and demand. Under those circumstances, the cash market may no longer be the appropriate point in the beef marketing channel at which the formula base price should be derived.

XI. FIGURES

Figure 1

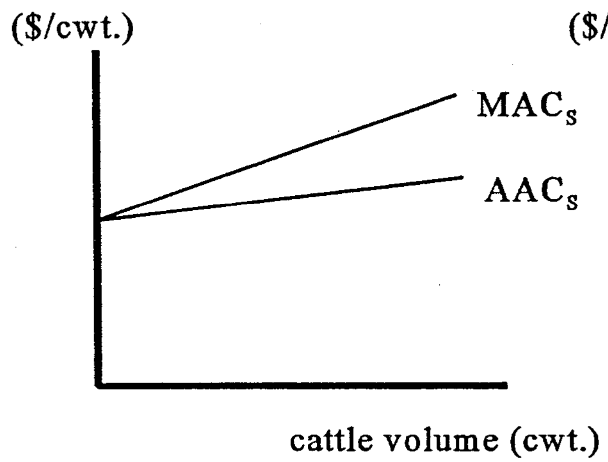


Figure 2

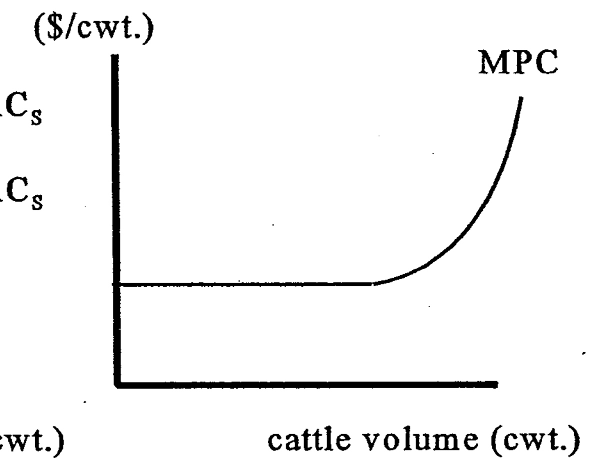


Figure 3

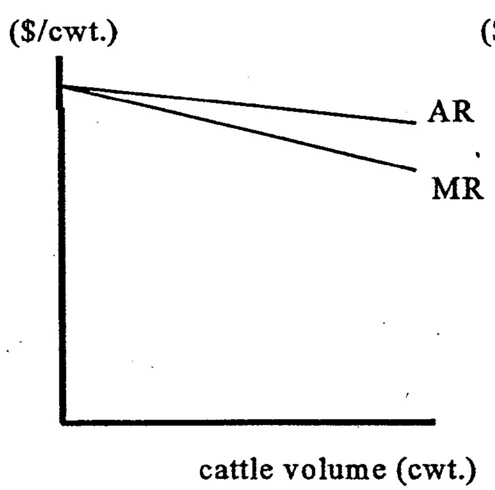
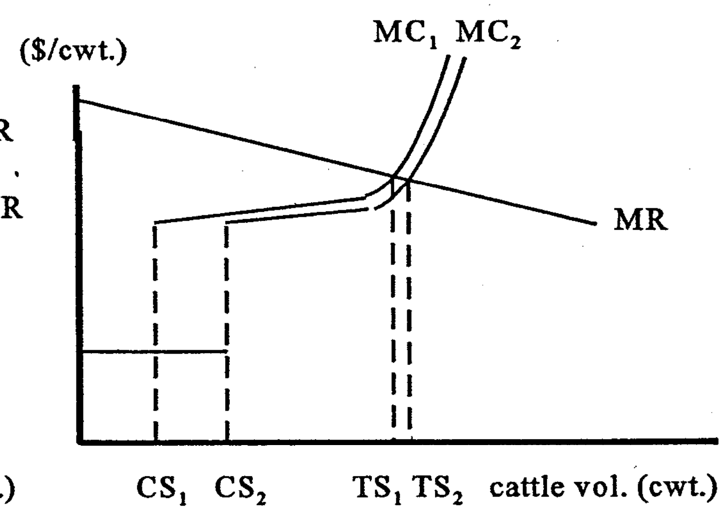


Figure 4



XII. TABLES

Table IV.1. Summary Statistics for the Distributions of the Distance (in miles) that Lots of Fed Cattle Were Shipped to the Plant; by Plant and by Procurement Method.

Table V.1. Percent of Non-cash Supplies of Fed Cattle Accounted for by Forward Contracted Cattle, Packer Fed Cattle, and Marketing Agreement Cattle.

Table V.2. Percent of Plant Slaughter of Fed Cattle Accounted for by Forward Contracted Cattle, Packer Fed Cattle, and Marketing Agreement Cattle.

Table VI.1.1. Summary Statistics on Characteristics of Cattle Lots, by Plant, by Procurement Method.[1]

[1]A note about sample sizes appears at the end of the table.

[2]Variable definitions appear at the end of the table.

Table VI.1.1. (continued)

Table VI.1.1. (continued)

Table VI.1.1. (continued)

Table VI.1.1. (continued)

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Table VI.1.1. (continued)

Table VI.1.1. (continued)

Table VI.1.1. (continued)

Table VI.1.1. (continued)

[1]For each plant and each procurement method the number of lots upon which these statistics are based is typically smaller than the corresponding number of lots reported in Table IV.1. Table IV.1 figures are based on all lots of fed cattle. The figures in this table are based only on the lots that were used in the product-characteristic price

function analysis reported in Tables VI.1.2, VI.1.3, and VI.1.4. That analysis omitted spot market lots that were not priced on a live-weight basis; and omitted spot, contract, marketing agreement, and packer fed lots that were purchased during the sample's last week; a week for which we had only an incomplete record of lots purchased.

[2]Variables are defined as follows:

HEAD =	number of cattle in the lot (head).
YIELD =	the lot's total hot weight divided by total live weight (%).
PCTPC =	percentage of the lot grading prime or choice (%).
PCTYG13 =	percentage of the lot achieving yield grades of 1, 2, or 3 (%).
MILES =	the distance the cattle were shipped to the plant (miles).

Table VI.1.2. Estimates of the price function used in the analysis of quality differences (equation (1)) using the sample of live-weight-priced, spot market lots purchased by .[1] The dependent variable (PRICE) is the FOB feedyard price of cattle in the lot, on a live-weight basis ($/cwt.).

R^2 = 0.9647 | Number of observations = 7423[2]

$\bar{R}^2$ = 0.9642 | F value = 2355.690

Independent variables[3]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
INTERCEPT	37.37823	2.33416	14.300
HEAD	0.00058	0.000093	6.293
YIELD	0.14415	0.00903	15.965
PCTPC	-0.00144	0.00062	-2.330
PCTYG13	0.03000	0.00152	19.751
MILES	-0.00158	0.00033	-4.823
MILES2	-0.0000011	0.0000008	-1.254
HEIFER	-4.50755	3.23778	-1.392
MIXED	-25.35539	7.13671	-3.553
AWS	0.04432	0.00606	7.310
AW2S	-0.000030	0.000004	-7.399
AWH	0.06467	0.00672	9.620
AW2H	-0.00005	0.0000048	-10.353
AWM	0.11714	0.01906	6.145
AW2M	-0.000082	0.000013	-6.163
MON	0.48528	0.05775	8.403
TUE	-0.02997	0.04586	-0.653
WED	0.19139	0.04380	4.370
THU	0.08529	0.04446	1.918
WKEND	0.27008	0.32707	0.826

[1]Separate regressions were run using the live-weight-priced, spot-market lots purchased by each of the other three plants. Those results, while not reported here, were qualitatively similar to

[2]See the footnote in the text for comments on the composition of the sample.
[3]The independent variables are defined as follows:

HEAD = number of cattle in the lot (head).
YIELD = the lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot graded prime or choice (%).
PCTYG13 = percentage of the lot achieving yield grades of 1, 2, or 3 (%).

MILES =	the distance the cattle were shipped to the plant (miles).
MILES2 =	the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER =	a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED =	a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
AWS =	the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).
AW2S =	the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).
AWH =	the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).
AW2H =	the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).
AWM =	the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).
AW2M =	the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).
MON =	a dummy variable equal to 1 if the lot was purchased on a Monday, and equal to 0 otherwise.
TUE =	a dummy variable equal to 1 if the lot was purchased on a Tuesday, and equal to 0 otherwise.
WED =	a dummy variable equal to 1 if the lot was purchased on a Wednesday, and equal to 0 otherwise.
THURS =	a dummy variable equal to 1 if the lot was purchased on a Thursday, and equal to 0 otherwise.
WKEND =	a dummy variable equal to 1 if the lot was purchased on a weekend, and equal to 0 otherwise.

Also included among the independent variables was a set of purchase week dummies for 66 of the 67 weeks represented in the sample. Estimates of these parameters and their standard errors are not reported here.

Table VI.1.3. Estimates of the price function used in the analysis of quality differences (equation (1)) using the sample of live-weight-priced, spot market lots purchased by .[1] The dependent variable (PRICE) is the delivered hot cost of cattle in the lot, on a carcass-weight basis ($/cwt).

$R^2 = 0.9645$ Number of observations = 7423[2]

$\bar{R}^2 = 0.9641$ F value = 2345.643

Independent variables[3]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
INTERCEPT	152.29976	3.81475	39.924
HEAD	0.00089	0.00015	5.864
YIELD	-1.34275	0.01475	-90.996
PCTPC	-0.00165	0.00101	-1.634
PCTYG13	0.04353	0.00248	17.534
MILES	0.00246	0.00054	4.594
MILES2	-0.000013	0.0000014	-9.288
HEIFER	-9.10369	5.29154	-1.720
MIXED	-46.26831	11.66362	-3.967
AWS	0.07037	0.00991	7.103
AW2S	-0.000047	0.0000066	-7.101
AWH	0.10810	0.01099	9.839
AW2H	-0.000082	0.0000079	-10.441
AWM	0.20187	0.03115	6.480
AW2M	-0.000141	0.000022	-6.437
MON	0.72944	0.09439	7.728
TUE	-0.10261	0.07496	-1.369
WED	0.29019	0.07158	4.054
THU	0.05997	0.07266	0.825
WKEND	0.20138	0.53453	0.377

[1]Separate regressions were run using the live-weight-priced, spot market lots purchased by each of the other three plants. Those results, while not reported here, were qualitatively similar to the

[2]See the footnote in the text for comments on the composition of the sample.
[3]The independent variables are defined as follows:

HEAD = number of cattle in the lot (head).
YIELD = the lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot graded prime or choice (%).
PCTYG13 = percentage of the lot achieving yield grades of 1, 2, or 3 (%).

MILES =	the distance the cattle were shipped to the plant (miles).
MILES2 =	the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER =	a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED =	a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
AWS =	the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).
AW2S =	the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).
AWH =	the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).
AW2H =	the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).
AWM =	the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).
AW2M =	the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).
MON =	a dummy variable equal to 1 if the lot was purchased on a Monday, and equal to 0 otherwise.
TUE =	a dummy variable equal to 1 if the lot was purchased on a Tuesday, and equal to 0 otherwise.
WED =	a dummy variable equal to 1 if the lot was purchased on a Wednesday, and equal to 0 otherwise.
THURS =	a dummy variable equal to 1 if the lot was purchased on a Thursday, and equal to 0 otherwise.
WKEND =	a dummy variable equal to 1 if the lot was purchased on a weekend, and equal to 0 otherwise.

Also included among the independent variables was a set of purchase week dummies for 66 of the 67 weeks represented on the sample. Estimates of these parameters and their standard errors are not reported here.

Table VI.1.4. Summary statistics for distributions of product-characteristic-price-function-based quality indices; by plant, by procurement method, and for each of two measures of price.

Table VI.2.1. Estimates of the regression used to determine if there are quality-adjusted price differences among spot market, contract, and marketing agreement cattle.

Dependent variable[1] = DPRICE

R^2 = 0.8976 Number of observations = 32,538[2]

$\bar{R}^2$ = 0.8973 F value = 3090.898

Independent variables[3]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
INTERCEPT	127.198849	2.438172	52.170
HEAD	0.000844	0.000102	7.260
YIELD	-0.955148	0.012203	-78.273
PCTPC	0.012231	0.000714	17.121
PCTYG13	0.034743	0.002496	13.921
MILES	0.001067	0.000410	2.602
MILES2	-0.000004	0.000001	-3.801
HEIFER	-26.478147	4.041810	-6.551
MIXED	-39.465030	9.211565	-4.284
CARCASS	-0.371363	0.101692	-3.652
AWS	0.073552	0.006030	12.197
AW2S	-0.000051	0.000004	-12.747
AWH	0.154617	0.009715	15.915
AW2H	-0.000113	0.000007	-16.228
AWM	0.182328	0.024816	7.347
AW2M	-0.000127	0.000017	-7.363
	-0.054433	0.037277	-1.460
	-0.585554	0.044356	-13.201
	-0.459479	0.046366	-9.910
M	2.258487	0.122528	18.432
M	1.510664	0.094067	16.059
M	1.640258	0.110003	14.911
M	0.519464	0.122781	4.231
C	2.235046	0.083977	26.615
C	2.462343	0.099649	24.710
C	2.000444	0.134053	14.923
C	-0.012915	0.191826	-0.067

[1]The dependent variable, DPRICE, is the delivered hot-cost of the lot, which includes both acquisition and transport cost, on a carcass-weight basis ($/cwt.)

[2]The original data set included 35,695 spot market, forward contract, and marketing agreement lots of fed cattle. Of these, three had to be dropped because of missing or obviously incorrect data entries. 812 spot market lots were deleted because the recorded entry for the lot's total delivered cost (which should include transport cost) was less than or equal to the entry for FOB feedyard cost (which should exclude transport cost). This inconsistency does not necessarily mean that the total delivered cost figure (which is used to compute the regression's dependent variable) is in error, but it at least casts some suspicion on its accuracy. An additional 2342 lots were dropped because the FOB feedyard cost, which is needed to preform the check described above, was not recorded. This brought the sample down to 32,538 observations.

[3]The independent variables are defined as follows:

HEAD =	number of cattle in the lot (head).
YIELD =	the lot's total hot weight divided by total live weight (%).
PCTPC =	percentage of the lot grading prime or choice (%).
PCTYG13 =	percentage of the lot achieving yield grades of 1, 2, or 3 (%).
MILES =	the distance the cattle were shipped to the plant (miles).
MILES2 =	the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER =	a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED =	a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
CARCASS =	a dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to 0 otherwise.
AWS =	the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).
AW2S =	the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).
AWH =	the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).
AW2H =	the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).
AWM =	the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).
AW2M =	the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).
	a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.
	a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.
	a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.
M	a dummy variable equal to 1 if the lot was a marketing agreement purchase by the and equal to 0 otherwise.
M	a dummy variable equal to 1 if the lot was a marketing agreement purchase by the , and equal to 0 otherwise.
M	a dummy variable equal to 1 if the lot was a marketing agreement purchase by the and equal to 0 otherwise.
M	a dummy variable equal to 1 if the lot was a marketing agreement purchase by the and equal to 0 otherwise.
C	a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.
C	a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.
C	a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

C a dummy variable equal to 1 if the lot was a contract purchase by the plant, and equal to 0 otherwise.

Also included among the independent variables was a set of kill week dummy variables for 66 of the 67 weeks represented in the sample. The estimates of these parameters and their standard errors are not reported here.

Table VII.1.1. The spot market cattle price - non-cash supply relationship at the plant-level with RRATIO defined using planning horizon 1.

Dependent variable[1] = RPRICE

$R^2 = 0.2067$ Number of observations = 17,853

$\bar{R}^2 = 0.2030$ F value = 55.797

Independent variables[2]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
INTERCEPT	-24.14658	1.18887	-20.310
RRATIO	-0.214910	0.06338	-3.391
HEAD	0.00033	0.000038	8.565
YIELD	0.122009	0.005095	23.947
PCTPC	0.000181	0.000310	0.584
PCTYG13	0.017359	0.000964	18.011
MILES	-0.000855	0.000171	-4.996
MILES2	-0.0000049	0.00000048	-10.266
HEIFER	-8.965112	1.797767	-4.987
MIXED	4.307604	3.796875	1.135
CARCASS	-1.423912	0.225760	-6.307
AWS	0.039168	0.003023	12.955
AW2S	-0.000026	0.000002	-13.030
AWH	0.071609	0.004012	17.850
AW2H	-0.000054	0.000003	-18.866
AWM	0.029370	0.009983	2.942
AW2M	-0.000021	0.000007	-3.082
	0.001754	0.012559	0.140
	-0.144722	0.015946	-9.076
	-0.269425	0.015418	-17.475
MON	0.008186	0.037981	0.216
TUE	0.008826	0.028677	0.308
WED	-0.035215	0.026903	-1.309
THU	-0.033539	0.028077	-1.195

[1]The dependent variable, RPRICE, is the price of cattle in the lot, FOB feedyard, on a live weight basis, minus the weighted average steer price, as reported by AMS, for the day of purchase of the lot, in \$/cwt.

[2]The independent variables are defined as follows:

HEAD =	number of cattle in the lot (head).
YIELD =	the lot's total hot weight divided by total live weight (%).
PCTPC =	percentage of the lot graded prime or choice (%).
PCTYG13 =	percentage of the lot achieving yield grades of 1, 2, or 3 (%).
MILES =	the distance the cattle were shipped to the plant (miles).
MILES2 =	the square of the distance the cattle were shipped to the plant (miles^2).
HEIFER =	a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED =	dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.

CARCASS =	a dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to zero if it was priced on a live-weight basis.
AWS =	the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.).
AW2S =	the square of the lot's average carcass weight, if the lot consists of steers; equal to 0 otherwise (lb.^{2}).
AWH =	the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.).
AW2H =	the square of the lot's average carcass weight, if the lot consists of heifers; equal to 0 otherwise (lb.^{2}).
AWM =	the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.).
AW2M =	the square of the lot's average carcass weight, if the lot consists of a mixture of steers and heifers; equal to 0 otherwise (lb.^{2}).
	a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.
	a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.
	a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.
MON =	a dummy variable equal to 1 if the day of purchase was a Monday, and equal to 0 otherwise.
TUE =	a dummy variable equal to 1 if the day of purchase was a Tuesday, and equal to 0 otherwise.
WED =	a dummy variable equal to 1 if the day of purchase was a Wednesday, and equal to 0 otherwise.
THURS =	a dummy variable equal to 1 if the day of purchase was a Thursday, and equal to 0 otherwise.

Also included among the independent variables was a set of purchase week dummies for 60 of the 61 weeks represented in the sample. Estimates of these parameters and their standard errors are not reported here.

Table VII.2.1. Ordinary least squares regression results from estimation of the price regression used in the construction of the ADJCPR series.

Dependent variable[1] = PRICE
F value = 5819.07
$\overline{R}^2$ = **0.9587**

Number of observations = 21,040[2]
R^2 = 0.9589

Independent variables[3]	Parameter estimate	Standard error	t-statistic[4] for H_0: parameter = 0
INTERCEPT	44.484	0.869	51.18
HEAD	0.000494	0.000044	11.16
YIELD	0.1613	0.0059	27.47
PCTPC	-0.000108	0.00036	-0.298
PCTYG13	0.02339	0.00110	21.28
MILES	-0.000955	0.000196	-4.877
MILES2	-0.0000062	0.0000005	-11.596
HEIFER	-0.1811	0.01496	-12.11
MIXED	-0.2677	0.02486	-10.77
CARCASS	-1.3189	0.2525	-5.223
ACW	0.01431	0.00210	6.808
ACW2	-0.0000110	0.0000014	-7.728
	-0.01720	0.01469	-1.170
	-0.21398	0.01853	-11.550
	-0.37290	0.01769	-21.079
MON	0.1783	0.03111	5.732
TUE	-0.1522	0.02494	-6.104
WED	0.02329	0.02288	1.018
THR	0.00332	0.02357	0.141
WKEND	-0.6270	0.1163	-5.391

[1]The dependent variable, PRICE, is the price of cattle in the lot, FOB feedyard, on a live weight basis, in \$/cwt.

[2]The original data set recorded 24,425 spot market purchases of fed cattle by the four Texas plants combined. Of these, 2,342 had to be deleted because the FOB feedyard price, the value of the regression's dependent variable, was not recorded. Three lots were dropped because of missing or obviously incorrect data entries. An additional 812 were deleted because the recorded entry for the lot's total delivered cost (which should include transport cost) was less than or equal to the entry for FOB feedyard cost (which should exclude transport cost). While this inconsistency does not necessarily mean that the value for FOB feedyard price (FOB feedyard cost divided by the lot's total live weight) is in error, it at least casts some suspicion on its accuracy. Finally, the sample was further restricted to the 66 weeks of the sample (the week of February 5, 1995 through the week of May 5, 1996) for which we had complete information on the cattle killed and at least nearly complete information on the cattle purchased.

[3]The independent variables are defined as follows:

HEAD = number of cattle in the lot (head).
YIELD = lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot graded prime or choice (%).
PCTYG13 = percentage of the lot achieving yield grades of 1, 2, or 3 (%).
MILES = the distance the cattle were shipped to the plant (miles).
MILES2 = the square of the distance the cattle were shipped to the plant ($miles^2$).
HEIFER = a dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.

MIXED = a dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.

CARCASS = a dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to 0 if it was priced on a live-weight basis.

ACW = the lot's average carcass weight (lbs.)

ACW2 = the square of the lot's average carcass weight (lb.^{2}).

a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.

a dummy variable equal to 1 if the lot was purchased by the equal to 0 otherwise.

MON, TUE, WED, THR, WKEND = dummy variables equal to 1 for the corresponding purchase day of the week, and equal to 0 otherwise.

Also included among the independent variables were a set of purchase week dummies for the first 65 of the sample's 66 weeks. Estimates of these parameters and their standard errors are not reported here. Point estimates ranged from about -5.7 (in week 64) to about 13.6 (in week 2). All but three of these parameter estimates were significant at the 0.01% level (in a two-tailed test).

[4]Except for the coefficients of the purchase day of the week dummies WED and THR, all parameter estimates are significant at the 0.01% level (in a two-tailed test).

Table VII.2.2. Regression results for equation 1 obtained using the Yule-Walker procedure for correcting for AR(1) errors.

	Parameter estimates for the model with dependent variable:[1]							
	AVGSPR	AVGSPR	AVGHPR	AVGHPR	AVGCPR	AVGCPR	ADJCPR	ADJCPR
Constant	7.847 (9.074)	10.999 (9.649)	7.177 (9.139)	10.368 (9.720)	7.297 (9.006)	10.578 (9.547)	7.153 (9.077)	10.740 (9.605)
AVGVAL	0.6151**** (0.0824)	0.5824**** (0.0872)	0.6223**** (0.0829)	0.5893**** (0.0878)	0.6164**** (0.0817)	0.5824**** (0.0862)	0.6176**** (0.0824)	0.5807**** (0.0868)
Q	0.0000158* (0.0000063)	0.0000150* (0.0000063)	0.0000149* (0.0000064)	0.0000141* (0.0000064)	0.0000167** (0.0000063)	0.0000159* (0.0000063)	0.0000168* (0.0000064)	0.0000159* (0.0000063)
CSTOT	-0.000089**** (0.000021)		-0.000090**** (0.000021)		-0.000085*** (0.000021)		-0.000084*** (0.000021)	
CSRAT		-6.7227** (2.0316)		-6.8280** (2.0484)		-6.2706** (2.0073)		-6.1921** (2.0263)
WEEK	-0.2262** (0.0682)	-0.2310** (0.0782)	-0.2272** (0.0684)	-0.2323** (0.0786)	-0.2222** (0.0677)	-0.2273** (0.0777)	-0.2172** (0.0674)	-0.2225** (0.0775)
WEEK2	0.00294** (0.00094)	0.00288** (0.00108)	0.00298** (0.00094)	0.00293** (0.00108)	0.00289** (0.00093)	0.00284* (0.00107)	0.00282** (0.00093)	0.00277* (0.00107)
RHO	0.5911**** (0.1050)	0.6431**** (0.0997)	0.5888**** (0.1052)	0.6417**** (0.0998)	0.5916**** (0.1050)	0.6453**** (0.0995)	0.5817**** (0.1059)	0.6400**** (0.1000)
R^2	0.7311	0.6774	0.7305	0.6766	0.7306	0.6770	0.7293	0.6740

[1]Standard errors appear in parentheses. Significance levels (in two-tailed tests) are indicated as follows:
0.01%: ****
0.1%: ***
1.0%: **
5.0%: *

Table VII.2.3. Regression results for equation 1 obtained using 2SLS.[1]

	Parameter estimates for the model with dependent variable:[2]							
	AVGSPR	AVGSPR	AVGHPR	AVGHPR	AVGCPR	AVGCPR	ADJCPR	ADJCPR
Constant	-11.646 (10.657)	-18.738 (11.421)	-11.668 (10.668)	-18.872 (11.446)	-12.666 (10.595)	-19.693 (11.347)	-12.524 (10.607)	-19.717 (11.382)
AVGVAL	0.8039**** (0.0898)	0.8572**** (0.0961)	0.8057**** (0.0899)	0.8601**** (0.0963)	0.8097**** (0.0893)	0.8626**** (0.0955)	0.8090**** (0.0894)	0.8632**** (0.0958)
Q	0.000022 (0.000023)	0.000025 (0.000024)	0.000021 (0.000023)	0.000025 (0.000024)	0.000023 (0.000023)	0.000026 (0.000024)	0.000023 (0.000023)	0.000027 (0.000024)
CSTOT	-0.000128**** (0.000030)		-0.000131**** (0.000030)		-0.000127**** (0.000029)		-0.000129**** (0.000029)	
CSRAT		-8.4167** (3.1378)		-8.6827** (3.1447)		-8.3176** (3.1175)		-8.4690** (3.1270)
WEEK	-0.2035*** (0.0513)	-0.1688** (0.0557)	-0.2064*** (0.0513)	-0.1721** (0.0559)	-0.1954*** (0.0510)	-0.1609** (0.0554)	-0.1922*** (0.0510)	-0.1575** (0.0555)
WEEK2	0.00323**** (0.00070)	0.00284*** (0.00076)	0.00328**** (0.00070)	0.00290*** (0.00076)	0.00314**** (0.00070)	0.00275*** (0.00076)	0.00309**** (0.00070)	0.00271*** (0.00076)
R^2	0.8376	0.8081	0.8380	0.8081	0.8380	0.8087	0.8374	0.8074

[1]The instruments used for two-stage least squares estimation included AVGVAL, WEEK, WEEK2, one period lags of AVGVAL and Q, and current and one-period-lagged CSTOT, for those models with CSTOT as a regressor, or current and one-period-lagged CSRAT, for those models with CSRAT as a regressor.

[2]Standard errors appear in parentheses. Significance levels (in two-tailed tests) are indicated as follows: 0.01%: ****; 0.1%: ***; 1.0%: **; 5.0%: *.

Table VIII.2.1. The results of ordinary least squares estimation of equation (7), the one-week-ahead price forecasting equation.

Dependent variable[1] = p_{t+1}
F value = 51.038
$\bar{R}^2$ = **0.8866**

Number of observations = 65
R^2 = 0.9043

Independent variables[2]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
constant	-29.1218	20.8919	-1.394
p_t	1.1878	0.1616	7.349
p_{t-1}	-0.4543	0.1675	-2.713
Δfp_t	-0.4285	0.1456	-2.944
val_t	-0.1422	0.0997	-1.427
r_t	2.1440	2.0700	1.036
cf_t	0.0077	0.0029	2.684
fcp_t	0.2537	0.2109	1.203
$crnp_t$	2.1846	1.5214	1.436
cpl_t	0.0274	0.0101	2.692
$lcpl_t$	0.0327	0.0123	2.656

[1]The dependent variable, p_{t+1}, is the average spot market price of steers in the Oklahoma-Texas panhandle region in week t + 1, in \$/cwt.

[2]The independent variables are defined as follows:

p_t = the value of the dependent variable in week t. (\$/cwt.)
p_{t-1} = the value of the dependent variable in week t - 1 (\$/cwt.)
Δfp_t = the change in the price of week t's "nearby" CME live cattle futures contract from the first reporting day of week t - 1 to the first reporting day of week t. (\$/cwt.) The "nearby contract" for week t is defined as the one associated with the first contract month to follow week t, assuming that the first day of the contract month is at least 7 days later than the first reporting day of week t. If the first day of a contract month is fewer than 7 days later, the next contract is taken as the "nearby contract."
val_t = the average boxed beef cutout value for week t. (\$/cwt.) This is exactly the same as the AVGVAL series used in section VII.2.
r_t = the 6-month Treasury bill secondary market rate on the Friday immediately prior to week t. (%)
cf_t = the number of cattle on feed in week t in Texas feedyards with capacity of 1000 head or more (1000 head).
fcp_t = the price of feeder cattle (Oklahoma City; steers: medium #1, 600-650 lbs) in week t (\$/cwt.).
$crnp_t$ = the price of feed corn (central Illinois; #2, yellow) in week t (\$/bu.).
cpl_t = the number of cattle placed on feed during week t in Texas feedyards with capacity of 1000 head or more (1000 head).
$lcpl_t$ = a simple average of the numbers of cattle placed on feed in weeks 15, 16, 17, and 18 weeks prior to week t in Texas feedyards with capacity of 1000 head or more (1000 head).

Table VIII.2.2. The results of ordinary least squares estimation of equation (9), the two-week-ahead price difference forecasting equation.

Dependent variable[1] = $p_{t+2} - p_{t+1}$
F value = 2.450
$\bar{R}^2$ = **0.1871**

Number of observations = 64
$R^2 = 0.3162$

Independent variables[2]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
constant	-1.1218	24.1126	-0.047
p_t	-0.6161	0.1753	-3.515
p_{t-1}	0.4430	0.1856	2.387
Δfp_t	0.1658	0.1591	1.042
val_t	-0.0662	0.1108	-0.597
r_t	3.1661	2.2489	1.408
cf_t	0.0021	0.0031	0.655
fcp_t	-0.1047	0.2401	-0.436
$crnp_t$	-0.0609	1.8061	-0.034
cpl_t	0.0170	0.0113	1.495
$lcpl_t$	0.0180	0.0135	1.332

[1]The dependent variable, $p_{t+2} - p_{t+1}$, is the difference in the average spot market price of steers in the Oklahoma-Texas panhandle region between weeks t + 1 and t + 2, in \$/cwt.

[2]The independent variables are defined as follows:

p_t = the average spot market steer price in week t. (\$/cwt.)
p_{t-1} = the average spot market steer price in week t - 1 (\$/cwt.)
Δfp_t = the change in the price of week t's "nearby" CME live cattle futures contract from the first reporting day of week t - 1 to the first reporting day of week t. (\$/cwt.) The "nearby contract" for week t is defined as the one associated with the first contract month to follow week t, assuming that the first day of the contract month is at least 7 days later than the first reporting day of week t. If the first day of a contract month is fewer than 7 days later, the next contract is taken as the "nearby contract."
val_t = the average boxed beef cutout value for week t. (\$/cwt.) This is exactly the same as the AVGVAL series used in section VI.2.
r_t = the 6-month Treasury bill secondary market rate on the Friday immediately prior to week t. (%)
cf_t = the number of cattle on feed in week t in Texas feedyards with capacity of 1000 head or more (1000 head).
fcp_t = the price of feeder cattle (Oklahoma City; steers: medium #1, 600-650 lbs) in week t (\$/cwt.).
$crnp_t$ = the price of feed corn (central Illinois; #2, yellow) in week t (\$/bu.).
cpl_t = the number of cattle placed on feed during week t in Texas feedyards with capacity of 1000 head or more (1000 head).
$lcpl_t$ = a simple average of the numbers of cattle placed on feed in weeks 15, 16, 17, and 18 weeks prior to week t in Texas feedyards with capacity of 1000 head or more (1000 head).

Table VIII.2.3. The results of estimation of equation (8), the two-week-ahead price forecasting equation, by the Hatanaka method.

Dependent variable[1] = p^*_{t+2} Number of observations = 63

F value = 14502 R^2 = 0.9997

$\bar{R}^2$ **= 0.9996**

Independent variables[2]	Parameter estimate	Standard error	t-statistic for H_0: parameter = 0
constant	-6.9551	28.6304	-0.243
p_t	0.6820	0.2613	2.610
p_{t-1}	-0.0506	0.2616	-0.193
Δfp_t	-0.2303	0.2105	-1.143
val_t	-0.1377	0.1233	-1.117
r_t	2.6604	2.8392	0.937
cf_t	0.0069	0.0036	1.906
fcp_t	0.0551	0.2674	0.206
$crnp_t$	0.6357	2.1021	0.302
cpl_t	0.0388	0.0133	2.925
$lcpl_t$	0.0278	0.0181	1.537

[1]The dependent variable in equation (8), p_{t+2}, is the average spot market price of steers in the Oklahoma-Texas panhandle region in week t + 2, in \$/cwt. As described in the text, the estimates reported here are obtained by OLS estimation of a transformed version of equation (8), involving a dependent variable that is a transformed version of p_{t+2}. This transformation of the dependent variable is what accounts for the fact that the R^2 and F value reported here are so dissimilar from those reported for the other forecasting equations in Tables VIII.2.1 and VIII.2.2.

[2]The independent variables are defined as follows:

p_t = the average spot market steer price in week t. (\$/cwt.)

p_{t-1} = the average spot market steer price in week t - 1 (\$/cwt.)

Δfp_t = the change in the price of week t's "nearby" CME live cattle futures contract from the first reporting day of week t - 1 to the first reporting day of week t. (\$/cwt.) The "nearby contract" for week t is defined as the one associated with the first contract month to follow week t, assuming that the first day of the contract month is at least 7 days later than the first reporting day of week t. If the first day of a contract month is fewer than 7 days later, the next contract is taken as the "nearby contract."

val_t = the average boxed beef cutout value for week t. (\$/cwt.) This is exactly the same as the AVGVAL series used in section VII.2.

r_t = the 6-month Treasury bill secondary market rate on the Friday immediately prior to week t. (%)

cf_t = the number of cattle on feed in week t in Texas feedyards with capacity of 1000 head or more (1000 head).

fcp_t = the price of feeder cattle (Oklahoma City; steers: medium #1, 600-650 lbs) in week t ($/cwt.).

$crnp_t$ = the price of feed corn (central Illinois; #2, yellow) in week t ($/bu.).

cpl_t = the number of cattle placed on feed during week t in Texas feedyards with capacity of 1000 head or more (1000 head).

$lcpl_t$ = a simple average of the numbers of cattle placed on feed in weeks 15, 16, 17, and 18 weeks prior to week t in Texas feedyards with capacity of 1000 head or more (1000 head).

Table VIII.2.4. Results of ordinary least squares estimation of equation (4a), by plant and for the four plants combined.[1]

Dependent variable[2] = QM_{t+2} Number of observations = 62

					Combined
Intercept	11810.7	15400.7	39340.3	15527.1	82078.8
	(2.270)	(2.485)	(2.884)	(1.940)	(3.324)
$E_t[p_{t+2}]$	-465.46***	-219.79	-1654.6***	-685.59***	-3025.4***
	(-3.046)	(-0.701)	(-2.772)	(-2.900)	(-3.044)
$E_t[p_{t+1}]$	304.58***	31.876	1223.4***	473.91***	2033.8***
	(2.351)	(0.124)	(2.401)	(2.325)	(2.331)
R^2	0.154	0.089	0.178	0.147	0.266

[1]t-statistics are in parentheses. They are based on standard errors, calculated using the Newey-West procedure, that are robust with respect to heteroscedasticity and autocorrelation. For the coefficients of $E_t[p_{t+2}]$ and $E_t[p_{t+1}]$, significance levels (in one-tailed tests) are indicated as follows: 1%: ***.

[2]The dependent variable is the number of marketing agreement cattle delivered, in week t + 2, to each of the four plants, or to the four plants combined.

Table VIII.2.5. Results of ordinary least squares estimation of equation (4b), by plant and for the four plants combined.[1]

Dependent variable[2] = QM_{t+2} Number of observations = 62

					Combined
Intercept	1578.2	3454.2	11871.4	2055.6	18959.5
	(7.138)	(10.246)	(20.429)	(5.865)	(16.814)
$E_t[p_{t+2} - p_{t+1}]$	-119.06	264.85	-1013.2**	-279.50	-1,146.9*
	(-0.750)	(1.069)	(-1.918)	(-1.245)	(-1.341)
R^2	0.008	0.018	0.071	0.022	0.033

[1]t-statistics are in parentheses. They are based on standard errors, calculated using the Newey-West procedure, that are robust with respect to heteroscedasticity and autocorrelation. For the coefficient of $E_t[p_{t+2} - p_{t+1}]$, significance levels (in one-tailed tests) are indicated as follows: 5%: **; 10%: *.

[2]The dependent variable is the number of marketing agreement cattle delivered, in week t + 2, to each of the four plants, or to the four plants combined.

Table VIII.2.6. Results of ordinary least squares estimation of equations (5a) and (6a) for the and for the four plants combined.[1]

Dependent Variable[2] = QC_{t+2} Number of observations = 62

				Combined	
	(5a)	(6a)		(5a)	(6a)
Intercept	4516.2	7250.6		10277.0	19412.9
	(0.359)	(0.539)		(0.352)	(0.646)
$E_t[p_{t+2}]$	-318.74			-1102.4	
	(-0.921)			(-1.213)	
$E_t[p_{t+1}]$	268.24			1013.4*	
	(1.254)			(1.512)	
$E_{t+1}[p_{t+2}]$		-502.29			-1725.6*
		(-0.965)			(-1.422)
p_{t+1}		408.76			1492.7**
		(1.228)			(1.831)
R^2	0.013	0.039		0.025	0.064

[1]t-statistics are in parentheses. They are based on standard errors, calculated using the Newey-West procedure, that are robust with respect to heteroscedasticity and autocorrelation. For the coefficients of $E_t[p_{t+2}]$, $E_t[p_{t+1}]$, $E_{t+1}[p_{t+2}]$, and p_{t+1}, significance levels (in one-tailed tests) are indicated as follows: 5%: **; 10%: *.

[2]The dependent variable is the number of forward contract cattle delivered in week t + 2, to the Excel-Friona plant or to the four plants combined.

Table VIII.2.7. Results of ordinary least squares estimation of equations (5b) and (6b) for the and for the four plants combined.[1]

Dependent Variable[2] = QC_{t+2} Number of observations = 62

				Combined	
	(5b)	(6b)		(5b)	(6b)
Intercept	1289.4 (3.336)	1283.6 (3.560)		4570.5 (4.683)	4559.2 (5.004)
$E_t[p_{t+2} - p_{t+1}]$	-312.11* (-1.531)			-1255.7** (-1.975)	
$E_{t+1}[p_{t+2}] - p_{t+1}$		-353.83* (-1.437)			-1356.0** (-2.100)
R^2	0.014	0.023		0.034	0.050

[1]t-statistics are in parentheses. They are based on standard errors, calculated using the Newey-West procedure, that are robust with respect to heteroscedasticity and autocorrelation. For the coefficients of $E_t[p_{t+2} - p_{t+1}]$ and $E_{t+1}[p_{t+2}] - p_{t+1}$, significance levels (in one-tailed tests) are indicated as follows: 5%: **; 10%: *.

[2]The dependent variable is the number of forward contract cattle delivered, in week t + 2, to the Excel-Friona plant or to the four plants combined.

Table IX.1. Ordinary least squares regression results from the price regression used in the investigation of hypothesis 4.

Dependent variable[1] = HOTCOST
F value = 2766.44
$\overline{R}^2$ = 0.9008

Number of observations = 24,361
R^2 = 0.9011

Independent variables[2]	Parameter estimate	Standard error	t-statistic[3] for H_0: parameter = 0
constant	130.738	1.934	67.61
HEAD	0.000728	0.000105	6.967
YIELD	-0.8933	0.01297	-68.865
PCTPC	0.01846	0.000814	22.664
MILES	0.000969	0.000127	7.631
HEIFER	-0.7684	0.03344	-22.977
MIXED	-1.0929	0.05506	-19.850
CARCASS	-3.2659	.04949	-65.991
PCTYG13	0.01904	0.002087	9.122
ACW	0.06015	0.00477	12.621
ACW2	-0.0000456	0.00000324	-14.062
MON	-0.06804	0.06907	-0.985
TUE	0.03724	0.05465	0.681
WED	0.08828	0.05127	1.722
THR	-0.06158	0.05349	-1.151

[1]The dependent variable, HOTCOST, is the lot's total delivered cost divided by total hot weight, in $/cwt.

[2]The independent variables are defined as follows:

HEAD = number of cattle in the lot (head).
YIELD = lot's total hot weight divided by total live weight (%).
PCTPC = percentage of the lot graded prime or choice (%).
MILES = number of miles the cattle were shipped to the plant (miles).
HEIFER = dummy variable equal to 1 if the lot consists of heifers, and equal to 0 otherwise.
MIXED = dummy variable equal to 1 if the lot consists of a mixture of steers and heifers, and equal to 0 otherwise.
CARCASS = dummy variable equal to 1 if the lot was priced on a carcass-weight basis, and equal to 0 if it was priced on a live-weight basis.
PCTYG13 = percentage of the lot achieving yield grades of 1, 2, or 3 (%).
ACW = lot's average carcass weight (lbs.)
ACW2 = square of the lot's average carcass weight.
MON, TUE, WED, THR = dummy variables equal to 1 for the corresponding purchase day of the week, and equal to 0 otherwise.

Also included among the independent variables were a set of kill week dummies for the first 66 of the sample's 67 weeks. Estimates of these parameters and their standard errors are not reported here. Point estimates ranged from about -7 (in week 65) to about 21 (in week 3). All but two of these estimates were significant at the 0.01% level (in a two-tailed test).

[3]Except for the coefficients of the purchase day of the week dummies, all parameter estimates are significant at the 0.01% level (in a two-tailed test).

Table IX.2. Ordinary least squares regression results for equation (10) used in the test of Hypothesis 4.

	Signs and t-statistics for estimates of β	
Packer (plant) Formulas	Results with marketing agreement deliveries measured in head	Results with marketing agreement deliveries measured as a proportion of weekly slaughter
	+1.213	+1.421
	-0.909	-1.184
	-0.024	-0.024
	-1.529	-0.702
	-1.599	-1.497
	-1.124	-1.278

XIII. Appendices

Appendix A: Information in the primary data set.

For each lot of 35 head or more purchased by the sample plants between early February 1995 through mid May 1996:

Unique number identifying the lot.
Identity of the purchasing plant.
Purchase date
Kill date
Identity and location of the seller
Number of head in lot
Whether the lot consisted of steers, heifers, steers and heifers mixed, or dairy cattle
Procurement method (forward contract, packer fed, marketing agreement, or spot)
Pricing method (carcass, formula carcass, live, formula live)
If formula priced, the particular formula used.
Total live weight of the lot
Total hot weight of the lot
Total cost delivered
FOB feedyard live cost for spot transactions
Percent of lot graded prime and choice combined
Percent of lot graded select and others combined
Percent of lot falling in each of five yield grade categories
Number of head condemned
Miles cattle shipped

Appendix B: Evidence on the scheduling of marketing agreement (formula) cattle.

1. O. Dean Alexander reporting May 11, 1995 conversation with

Terms of agreements with

does not guarantee any numbers. has complete discretion over how many cattle to sell and when to sell them. at least 8 days notice before sending cattle. said that their notice rarely ever goes beyond the 8 days."

2.

"All formula feeders/customers will notify the head buyer at each plant on the 20th day of the month prior to shipment, of the approximate number of cattle they plan to ship the following month. The formula feeder/customer will then notify the head buyer on Thursday two weeks prior to shipment of the actual head count for the applicable week. For example, if a feeder thinks that he will have 1000 head to kill in April, he will notify the head buyer at the plant on or before the 20th of March. Then, if he wants to kill 245 head (of the 1000 head estimated) on April 19, 1995 (Wednesday), he will schedule these cattle with the head buyer on or before April 6, 1995 (Thursday)."

3. accompanying letter to P&SA from

"Cattle shipments to be determined by by second Thursday preceding the week of shipment."

4. Harry Schaaf and Sue Ann Claudon reporting April 30, 1997 interview of

schedules cattle for shipment and is the point man for all cattle sales. advises the packer two weeks in advance of what cattle will be shipped. can amend the figure during the following week, just as the packer can."

5. Report of November 1996 interview with

"He calls in the formula cattle two weeks before they would be ready or finished."

6. Harry Schaaf and Angie Williams report on November 18, 1996 interview of

"He said he provides both packers a list on Sunday for the week after next for formula cattle. Both packers have given him scheduling rights."

7. Report on interview of

"He sells some cattle on the formula . . . There is no standard seven day pick up with the formula and the packers can schedule at any date."

8. Harry Schaaf and Angie Williams report on interview of

turns the numbers in to the buyer on a Thursday, and these cattle will be scheduled for kill sometime during the week after next. In other words, the plant has advance notice of these cattle from 11 to 15 days."

Appendix C: Discussion of results of estimation of the plant-level spot market cattle price - non-cash supply relationship with RRATIO defined using planning horizon 1.

This appendix discusses some general aspects of the results reported in Table VII.1.1. The implications of the estimate of the coefficient of RRATIO are discussed in the body of the report. Interpretation of the estimates of the coefficients of other explanatory variables is provided here. The plant-level spot market cattle price - non-cash supply relationship was also estimated with RRATIO defined in terms of planning horizons 2 and 3. Those results (not reported here) were very similar to the results presented in Table VII.1.1

The regression's R^2 value of 0.2067 indicates that just over 20% of the variation in the model's dependent variable is explainable in terms of the regressors. While this proportion may seem "low," it should be borne in mind that the dependent variable is defined as the price of each sample lot's cattle *expressed as a departure from the region's average cattle price for the day of purchase.* Thus, a considerable portion of the variation in lot prices is already removed; this regression seeks to explain the residual variation. Collectively, the explanatory variables contribute significantly to the explanation of the variation in the dependent variable: The F value of 55.797 enables a rejection, at the 0.01% significance level, of the hypothesis that all parameters (other than the intercept term) are zero.

The estimate of the coefficient of HEAD is significantly positive. Other things equal, packers pay higher prices for spot market cattle sold in larger lots; perhaps because the purchase of a few large lots reduces transactions costs relative to the alternative of buying numerous small lots. The effect is relatively small, however. Average lot size in the sample was 190 head with a standard deviation of 127 head. The coefficient estimate predicts that an increase in lot size by one sample standard deviation would increase the price of cattle by about $0.04/cwt.

The estimate of the YIELD coefficient is significantly positive. The implication of the regression results is that higher-yielding cattle are paid higher live-weight prices, but lower prices on a $/cwt. carcass basis. The sample's average value of YIELD is about 63.79%. A lot of cattle yielding 1 percentage point higher than average (roughly the standard deviation of the sample's distribution of YIELD values) would receive a price $0.12/cwt. higher than average on a live-weight basis, but $1.38/cwt. lower than average on a carcass-weight basis.

The estimate of the coefficient of PCTPC was positive but statistically insignificant. This was a surprising result. We had expected that the percentage of the lot grading prime and choice would have been positively correlated with price, other things equal. Results suggest that the findings with regard to the price effects of PCTPC are sensitive to the definition of price and the sample used. For example, in the price regression reported in Table VI.1.2, with FOB feedyard price as a dependent variable and using the sample of live-weight-priced spot market cattle purchased by the estimated coefficient of PCTPC is significantly negative. On the other hand, in the price regression reported in Table VI.2.1, with delivered hot cost as the dependent variable and using the sample of all spot, marketing agreement, and forward contract lots, the estimated coefficient of PCTPC is strongly significantly positive.

The estimate of the coefficient of the percentage of the lot achieving yield grades 1, 2, or 3 is significantly positive. The value of the point estimate implies that a one sample standard deviation increase in PCTYG13 (about 6 percentage points) is rewarded with an additional $0.10/cwt.

The average distance cattle were shipped to the plant was 60 miles with a standard deviation of 61 miles. The estimates of the coefficients of MILES and MILES2 combine to imply that a lot of cattle shipped a distance that is one standard deviation greater than the mean distance would, other things equal, be paid about $0.11/cwt. less than a lot shipped the mean distance.

Dummy variables identifying lots of heifers and mixed lots (including steers and heifers) were included to allow for the possibility that such lots might receive a price that is discounted relative to the price paid for steers. The estimates of the coefficients of these dummy variables are difficult to interpret in isolation, however. The estimate of the coefficient of HEIFER, -8.96, when taken at face value, implies that a lot of heifers would suffer a very large price discount of nearly $9.00/cwt. relative to a lot of steers, *other things equal.* This comparison is not particularly meaningful, however, because other things, notably average carcass weight, typically are not equal for steers and heifers.

A very small proportion of the lots in the sample (about 0.03%) were priced on a carcass-weight basis instead of a live-weight basis. The significantly negative estimate of the coefficient of CARCASS implies that these lots suffered a $1.42/cwt. discount relative to otherwise-comparable lots priced on a live-weight basis. Carcass-weight pricing is generally reserved for the relatively few lots for which the ultimate yield is thought to be particularly unpredictable on the purchase date. The estimate of $1.42/cwt. can be thought of as a discount applied to cattle, not for low yield (because that is separately accounted for through the inclusion of YIELD in the regression equation), but for uncertainty with respect to yield.

Because ideal carcass weight differs with the sex of cattle, the variables average carcass weight and the square of the average carcass weight were included separately for lots of steers, of heifers, and of steers and heifers mixed. Estimates imply that the highest-valued carcass weights were 750.60 lb., 660.77 lb., and 694.88 lb. for steer lots, heifer lots, and mixed steer and heifer lots, respectively, with, in each case, drop-offs in value for heavier and lighter carcasses. This appears to be roughly consistent with packer preferences as reflected in many marketing agreement pricing formulas. The formula, for example, uses a base carcass characterized, in part, by the weight range 550 - 945 lbs., with discounts applied to both heavier and lighter carcasses.

The estimates of the coefficients of the three plant dummy variables show that, other things equal, prices paid by were insignificantly different from prices paid by the , while prices paid by the Monfort and IBP plants were $0.14/cwt. and $0.27/cwt. lower, respectively. These estimates include the effects of any not-otherwise-accounted-for plant-specific factors including the plants different average propensities to employ non-cash procurement methods.

The estimates of the coefficients of the purchase-day-week dummy variables ranged in magnitude from less than $0.01/cwt. to about $0.035/cwt., but none achieved statistical significance at conventional levels. Controlling for the other factors represented in the regression equation, there appear to be no significant differences in prices paid across days of the week.

Finally, the regression equation also included a set of purchase week dummy variables for 60 of 61 of the weeks represented in the sample. The estimates (not reported in Table VI.1.1) of the coefficients of these variables ranged in magnitude from -$0.36/cwt. to +$0.57/cwt. with several achieving significance at the 5% level or better.

Appendix D: Interpretation of the price regression used in the analysis of hypothesis 4.

The dependent variable in the price regression is HOTCOST, the lot's total delivered cost divided by total hot weight, measured in $/cwt. Data consist of 24,361 lots of fed cattle purchased by the four plants over the sample period. The regression's "F value" is significant at the 0.01% level, indicating that one can confidently reject the hypothesis that the set of explanatory variables, as a group, is irrelevant to the determination of HOTCOST. Indeed, variation in the explanatory variables accounts for about 90% of the lot-to-lot variation in HOTCOST. ($R^2 = 0.9011$) The individual parameter estimates are of predictable signs and most are significant at the 0.01% level. We turn now to an interpretation of each parameter estimate.

The estimate of the coefficient of lot size is significantly positive. Other things equal, packers pay higher prices for cattle sold in larger lots; perhaps because the purchase of a few large lots reduces transactions costs relative to the alternative of buying numerous small lots. The effect is relatively small, however. Average lot size in the sample was 180 head. The regression results predict that a lot of double average size would sell for only $0.13/cwt. more than an otherwise identical lot of average size.

The estimate of the YIELD coefficient is very strongly significantly negative. Evidently the live weight pricing employed in over 90% of the sample's spot market purchases does not fully "reward" high-yielding cattle: Other things equal, high-yielding cattle are paid a live-weight-delivered price that is less than commensurately higher than the price paid to low-yielding cattle, with the result that hot cost (delivered price per pound carcass weight) is actually lower for high-yielding cattle. The effect, moreover, is not insignificant in magnitude. In our sample, the mean of YIELD was 63.69%. A lot of steers with sample average characteristics (including yield) would receive a delivered price of $101.63/cwt. carcass or $64.72/cwt. live. An otherwise identical lot of steers with a yield that was higher by 1 percentage point (roughly the standard deviation of the sample's distribution of YIELD values) would receive a delivered price $0.44/cwt. higher on a live weight basis but $0.89/cwt. lower on a carcass weight basis.

A significantly positive estimate was obtained for the coefficient of the percentage of the lot grading prime and choice combined, PCTPC. A one standard deviation (16 percentage point) increase in the value of this lot quality indicator results in a $0.29/cwt. increase in delivered hot cost.

The average distance cattle were shipped to the plant was 83 miles. The standard deviation of the distribution of miles shipped was approximately 100 miles. The significantly positive estimate of the coefficient of MILES implies that a 100 mile increase in distance shipped results in roughly a $0.10/cwt. increase in delivered hot cost.

Lots of heifers and of mixed steers and heifers are discounted relative to lots of steers by $0.77/cwt. and $1.09/cwt. respectively. Spot market lots priced on a carcass weight basis have a delivered hot cost about $3.27/cwt. lower than otherwise equivalent lots priced on a live weight basis. Generally, carcass weight pricing is reserved for the relatively few lots (about 9% of our sample) for which the ultimate yield is thought to be particularly unpredictable on the purchase date. The estimate of $3.27/cwt. can be thought of as a discount applied to cattle, not for low yield (because that is separately accounted for in the regression equation), but for uncertainty with respect to yield.

The estimate of the coefficient of the percentage of the lot achieving yield grades 1, 2, or 3 is significantly positive. The value of the point estimate implies that a one sample standard deviation increase in PCTYG13 (about 6 percentage points) is rewarded with an additional $0.11/cwt. in delivered hot cost.

The estimates of the coefficients of average carcass weight and the square of average carcass weight are both significant. Together they imply that the highest-valued carcass weighs approximately

660 lbs., with drop-offs in value for heavier and for lighter carcasses. This appears to be consistent with packer preferences as reflected in many marketing agreement pricing formulas. The formula, for example, uses a base carcass characterized, in part, by the weight range 550-945 lbs., with discounts applied to both heavier and lighter carcasses.

The estimates of the coefficients of the purchase day of the week dummies are generally insignificant. Point estimate values suggest that representative prices for Monday through Thursday purchases range from $0.07/cwt. below to $0.09/cwt. above typical Friday prices.

Finally, the price regression also included a set of kill week dummies for the first 66 of the sample's 67 weeks. Although not reported in Table 2, point estimates of these parameters ranged from about -$7.00/cwt., in week 65, to about $21.00/cwt., in week 3. All but two of these parameter estimates were significant at the 0.01% level (in a two-tailed test).

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